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(54) **SURGICAL CUTTING GUIDE, SURGICAL ALIGNMENT GUIDE AND SURGICAL INSTRUMENT SYSTEM**

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CPC ..... **A61B 17/155** (2013.01)

(58) **Field of Classification Search**

USPC ..... 606/87–89, 96–98

See application file for complete search history.

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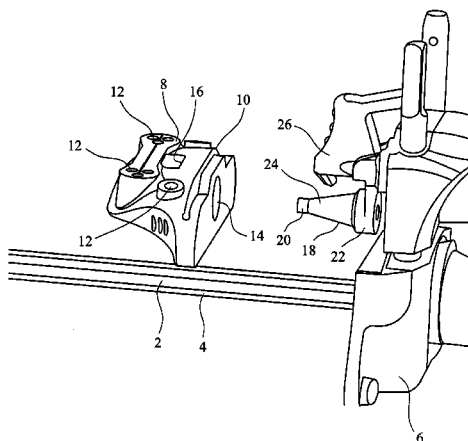
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Primary Examiner — Sameh Boles

(57) **ABSTRACT**

A surgical cutting guide (8) is described which comprises a body section delimiting a recess (14) extending into the body section from an external surface. The recess has a central axis and is for receiving an attachment protrusion (18) from a surgical alignment guide (6). The recess comprises: a first portion (36) having a first constant cross section along the central axis; and a second portion (38) having a second constant cross section along the central axis which is larger than the first constant cross section. The first and second portions are coaxial with the central axis and the second portion is closer to the external surface than the first portion. This configuration creates a stepped surface in the recess which is engaged by corresponding features on a protrusion of a surgical alignment guide. The attachment protrusion (18) of the alignment guide (6) has a central axis and comprises: a first portion (20) having a first constant cross section along the central axis; and a second portion (22) having a second constant cross section along the central axis that is larger than the first constant cross section. The first portion is further away than the second portion, and the first and second portions are coaxial with the central axis. The surgical cutting guide and surgical alignment guide form a system in which the alignment guide can be removed more easily from the cutting guide because there is more freedom of movement once the stepped surfaces are disengaged.

12 Claims, 22 Drawing Sheets



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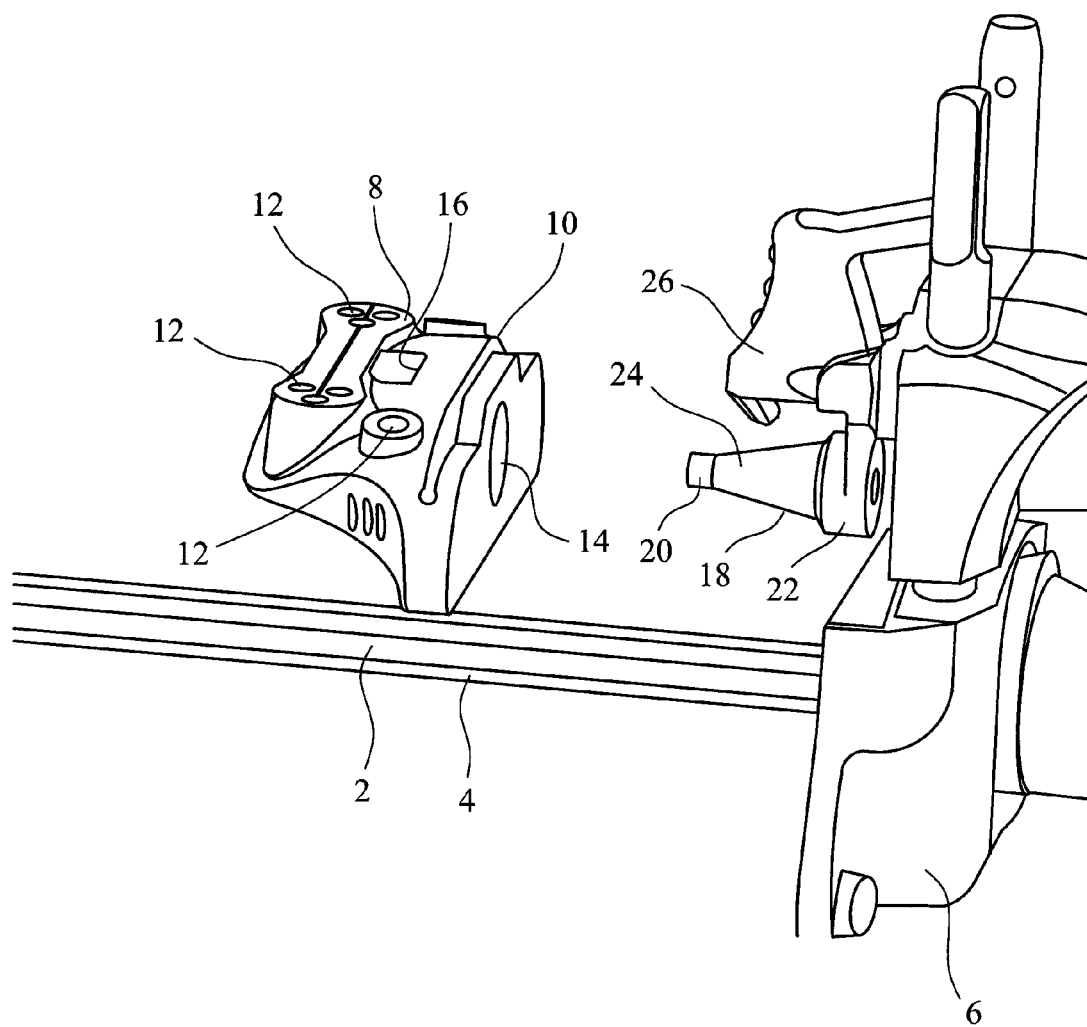


FIG. 1

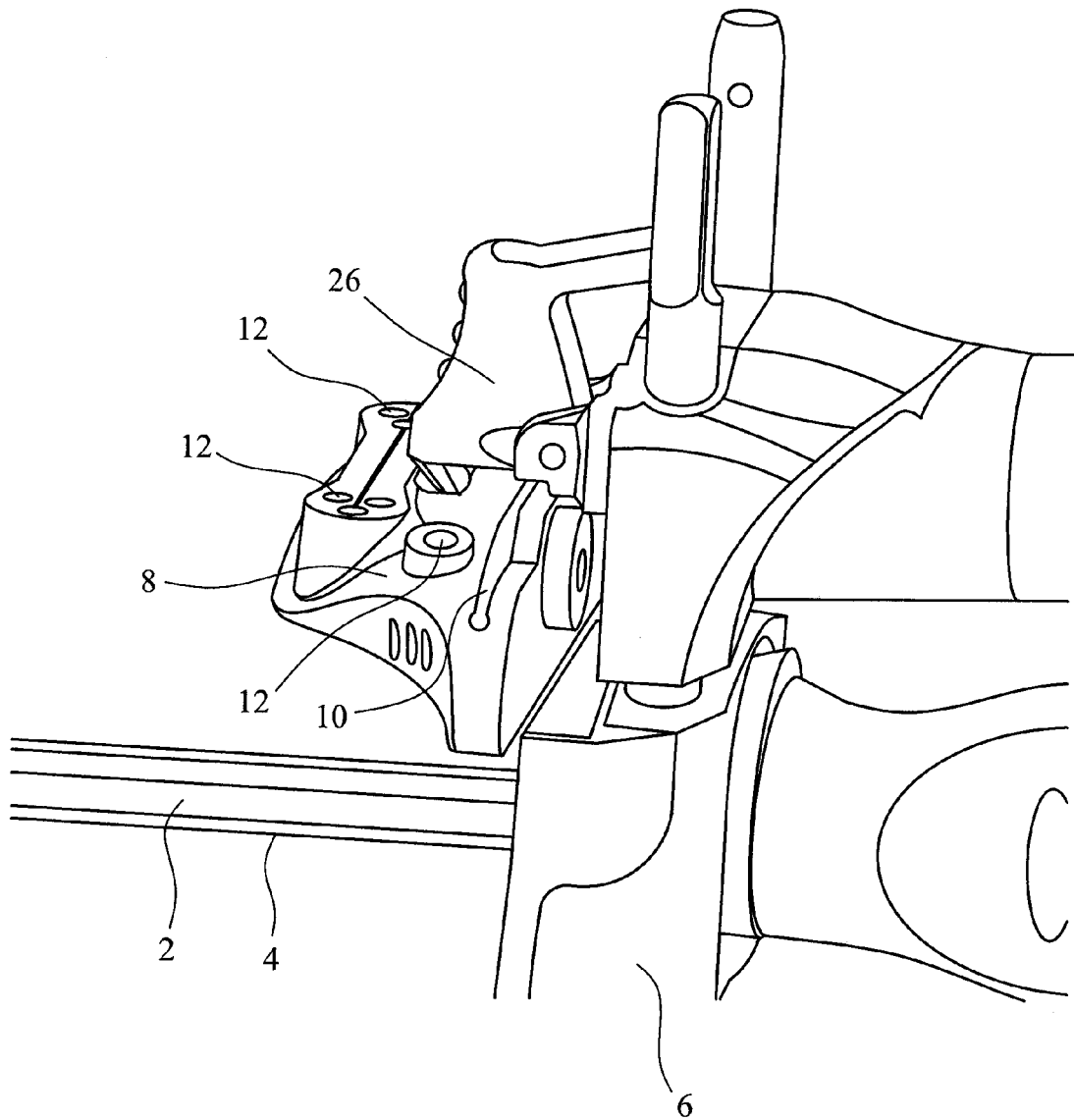


FIG. 2

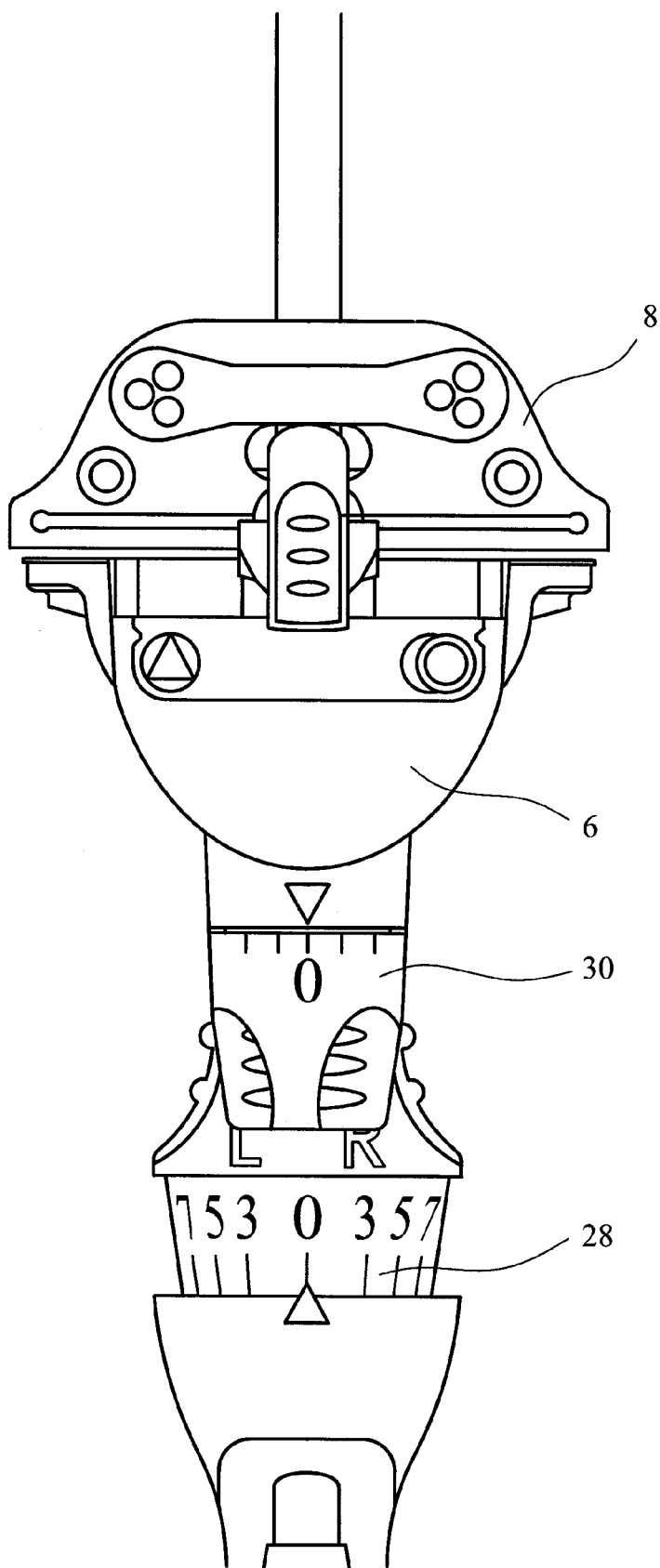


FIG. 3

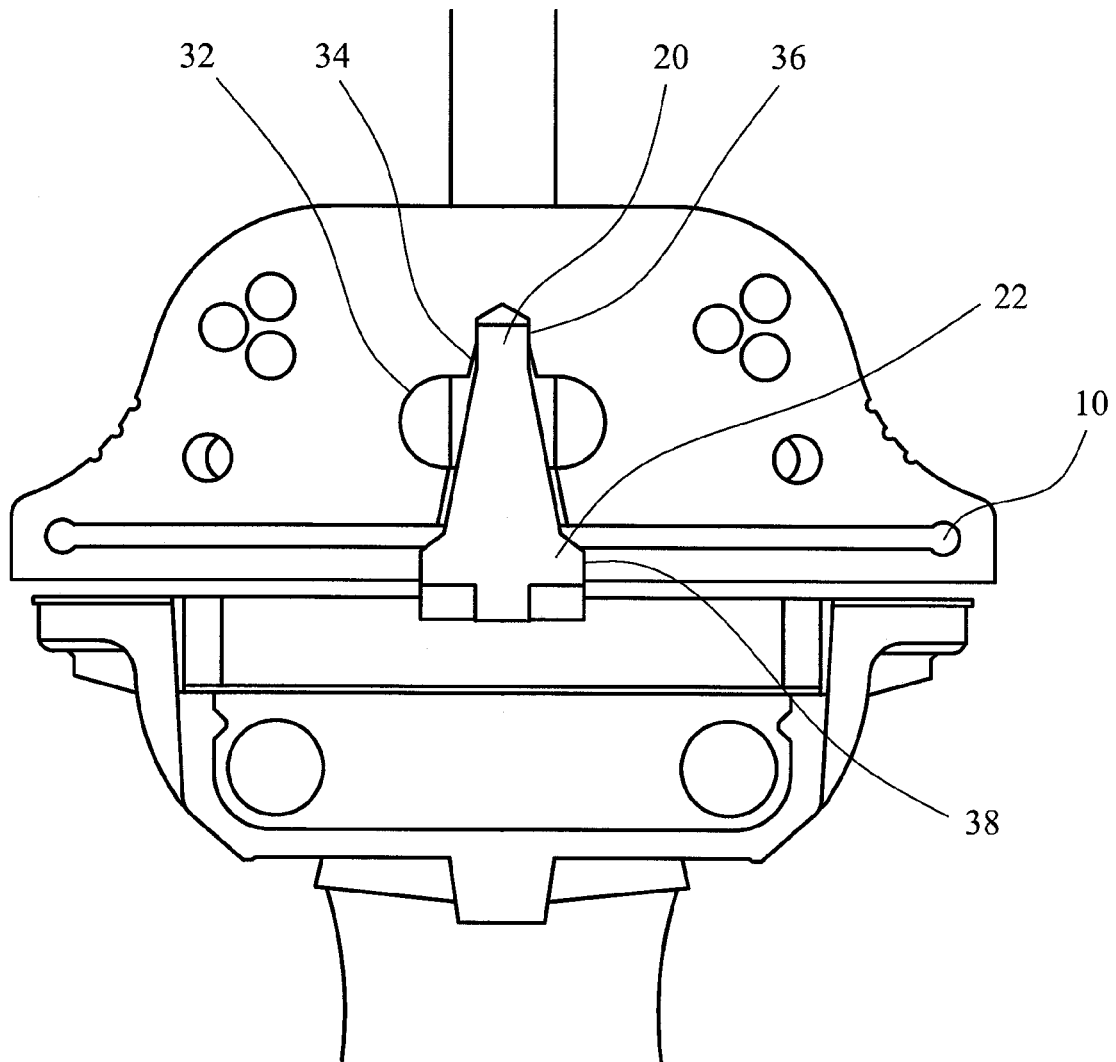


FIG. 4

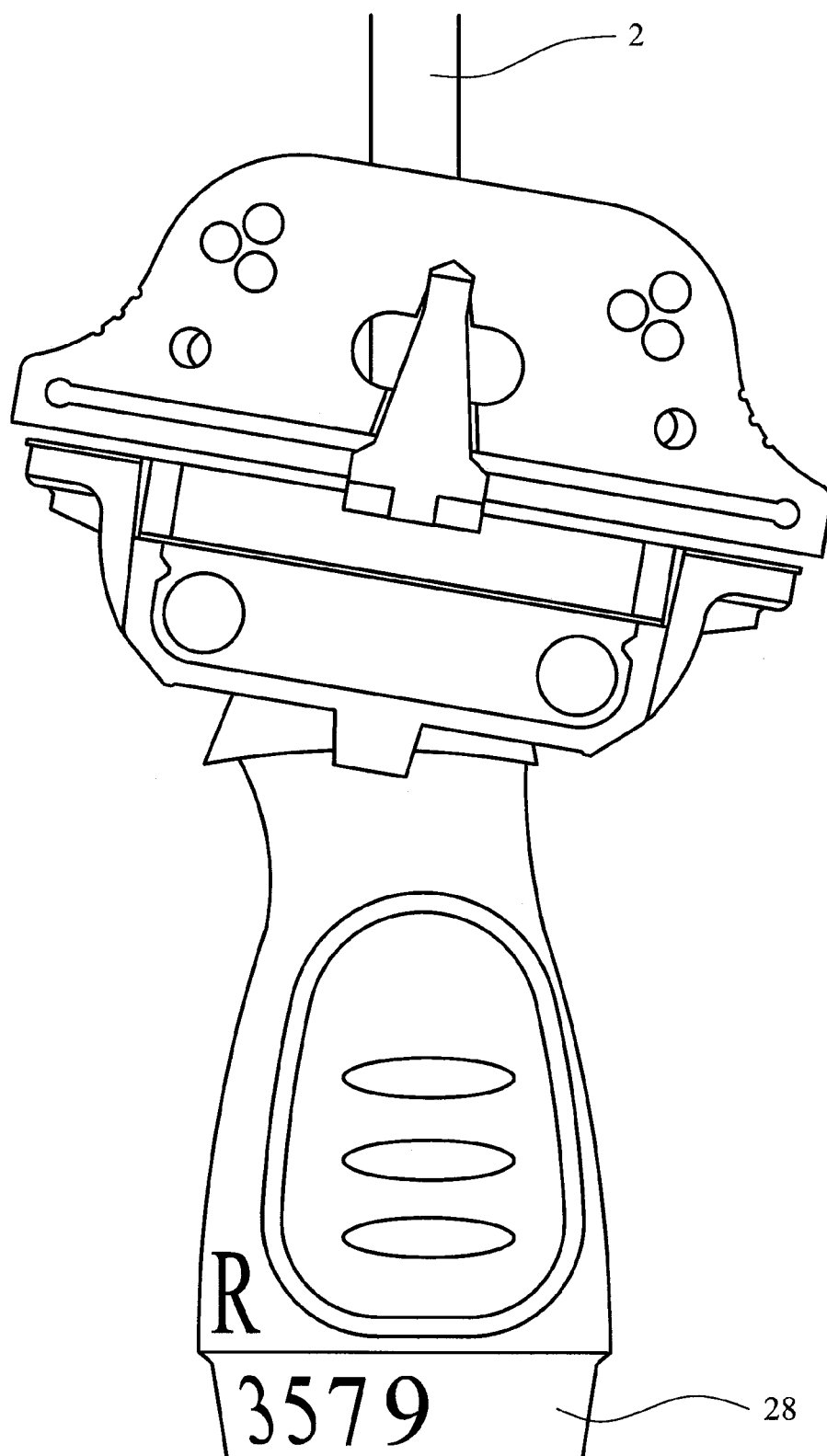


FIG. 5A

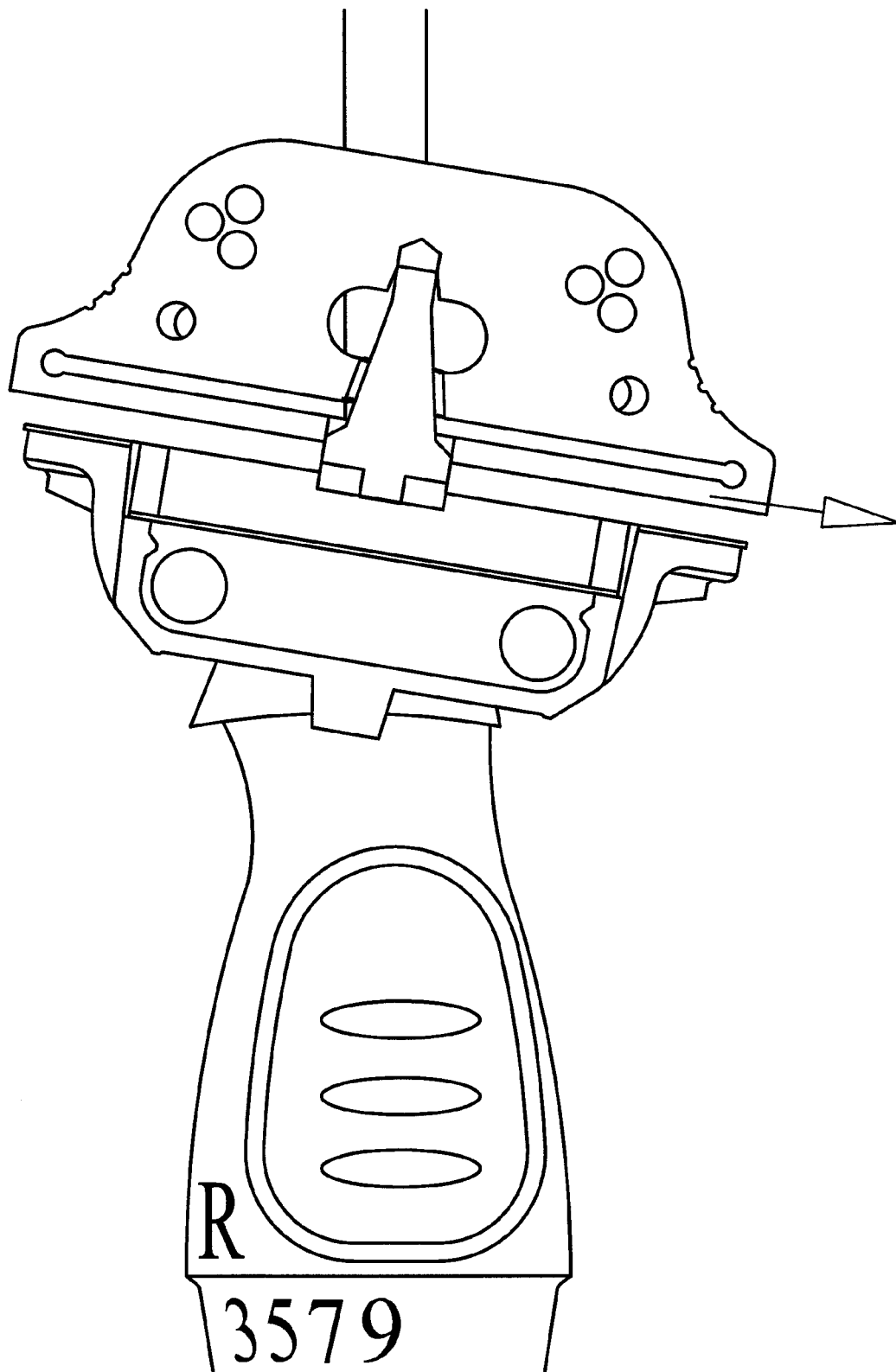


FIG. 5B



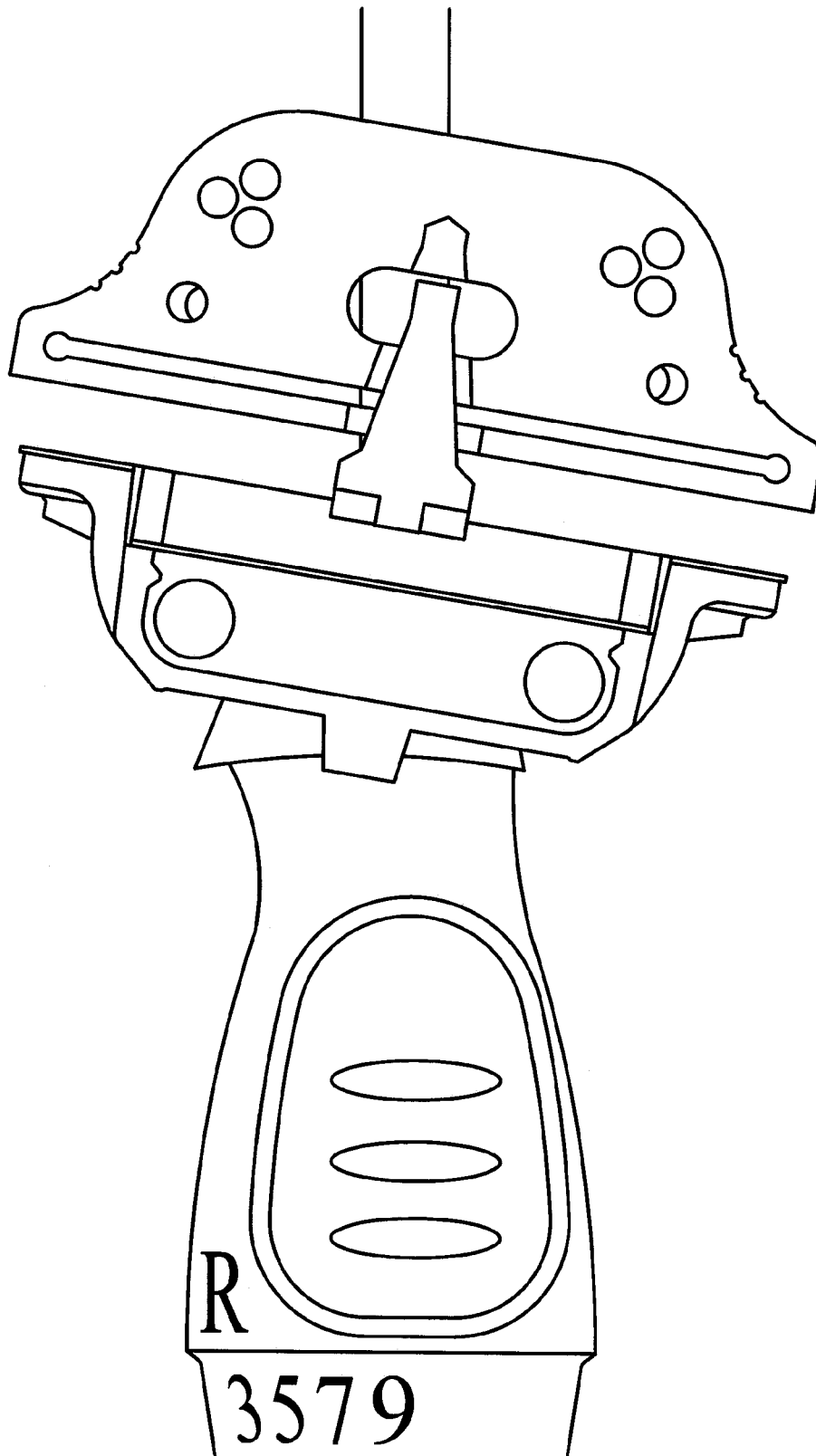


FIG. 5C

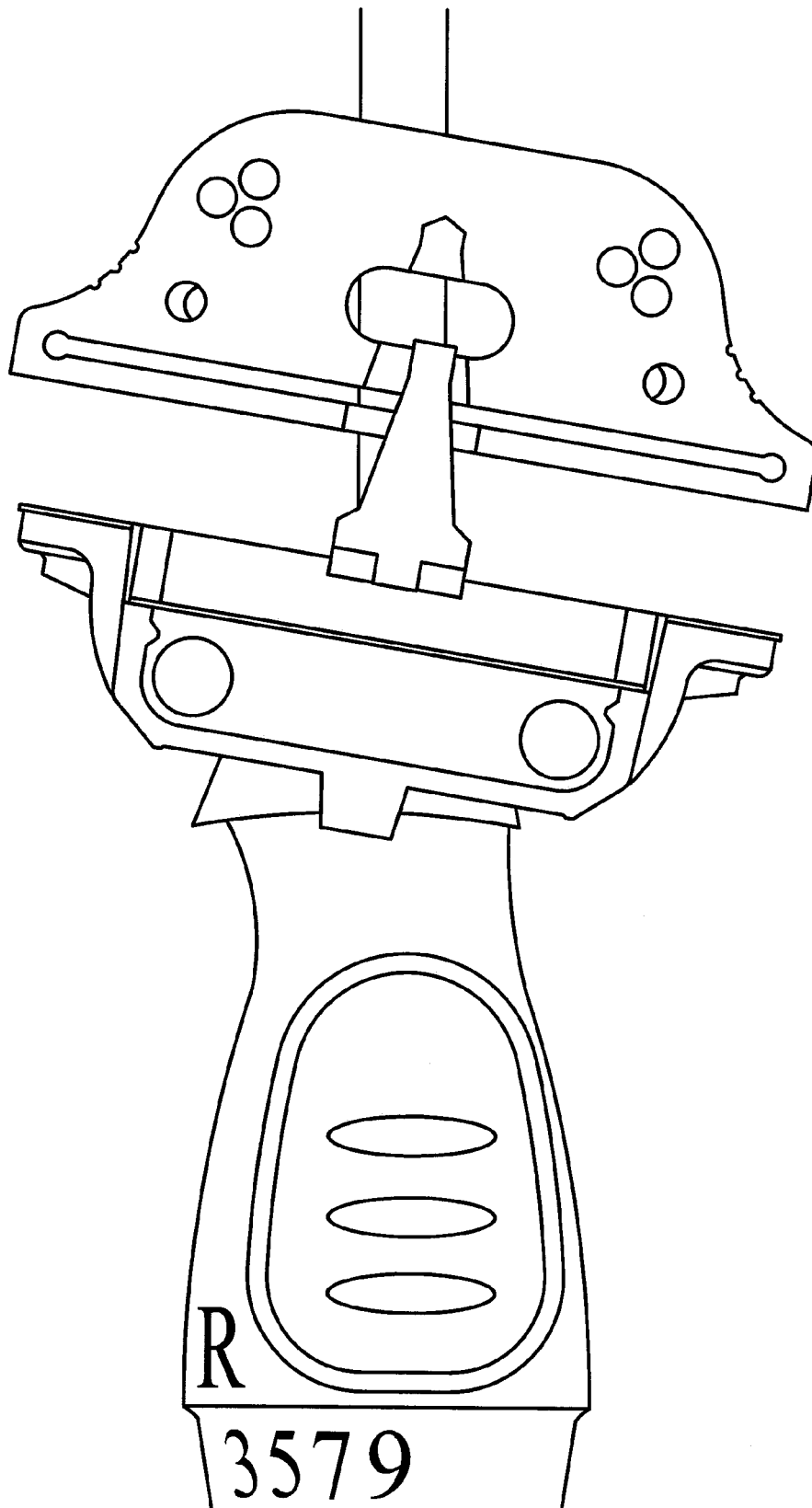


FIG. 5D

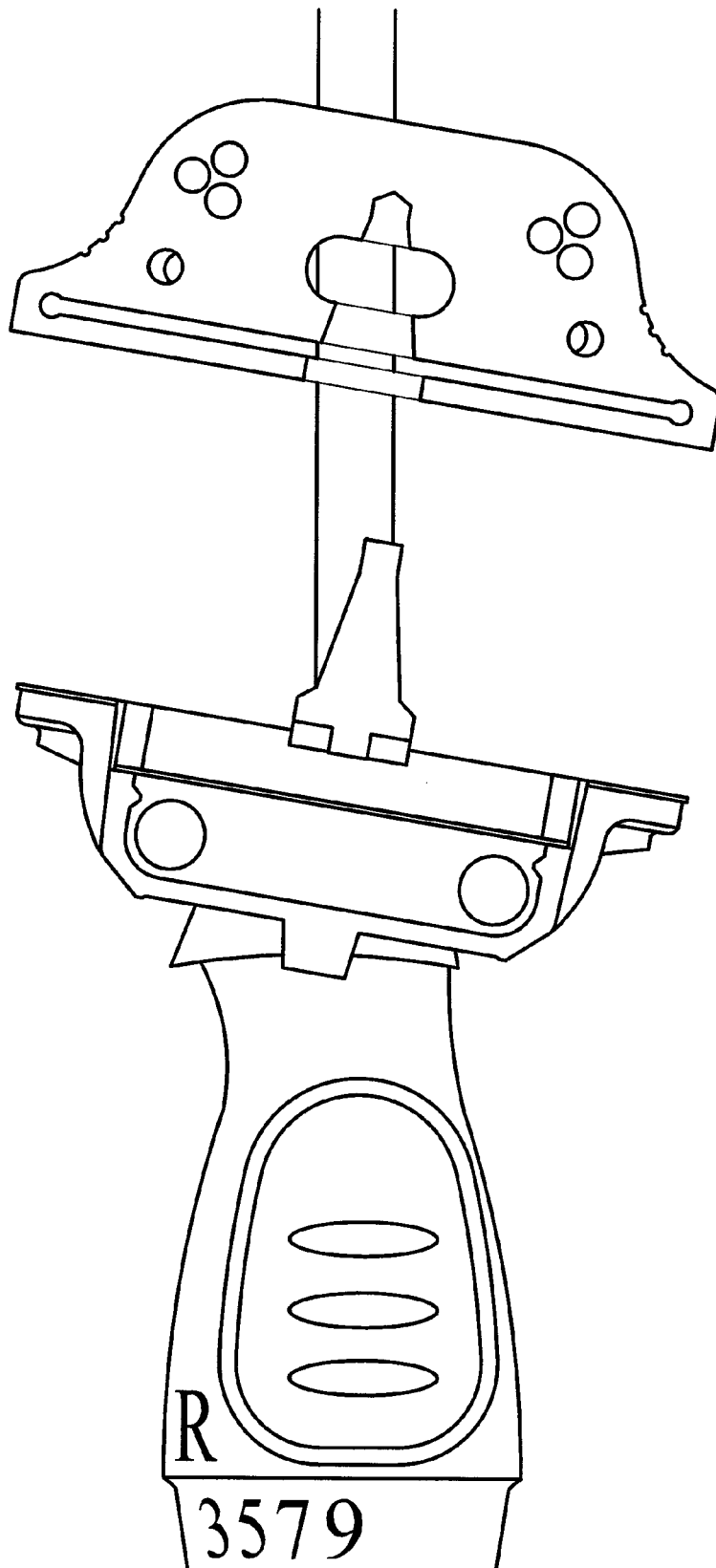


FIG. 5E

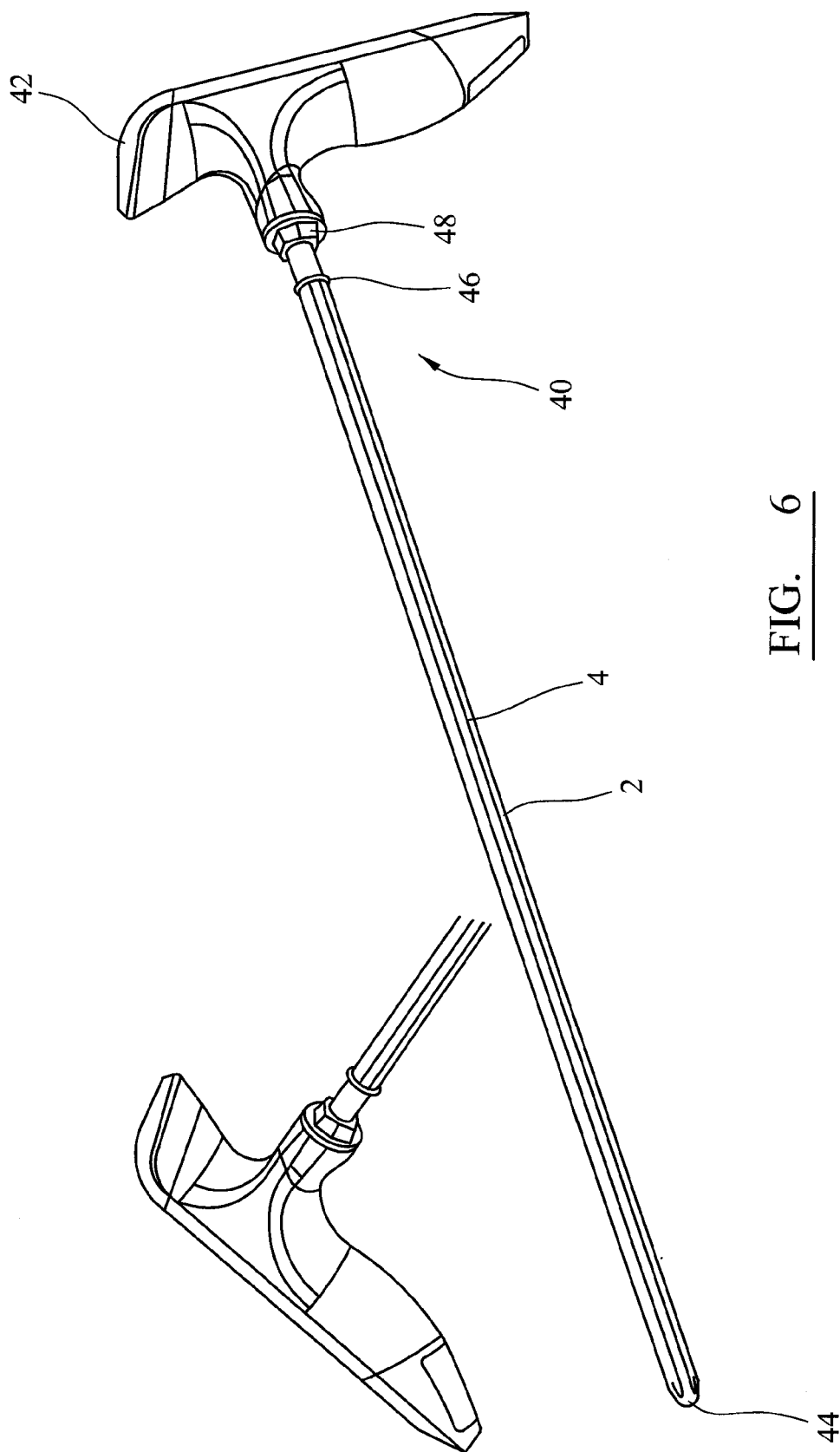
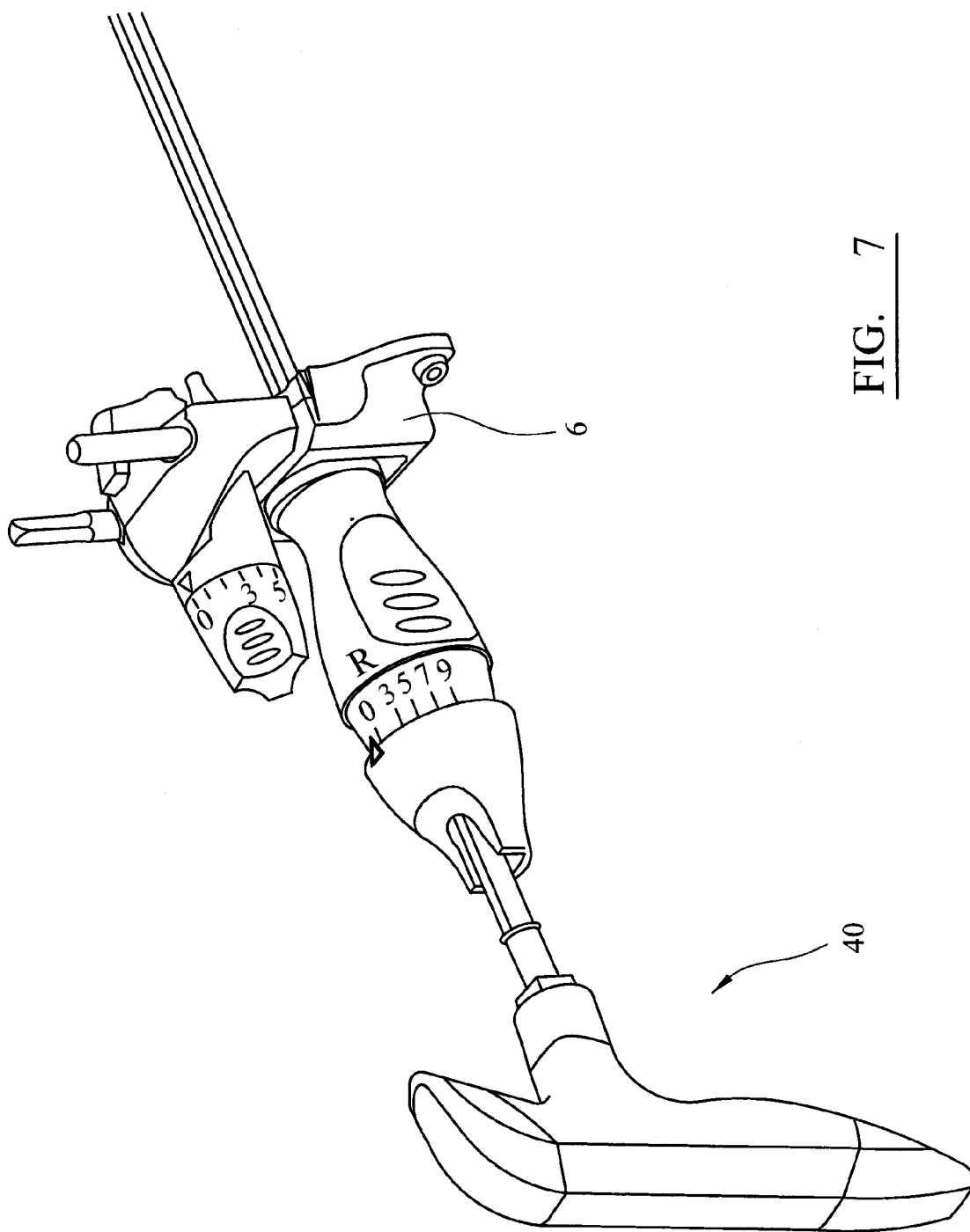


FIG. 6



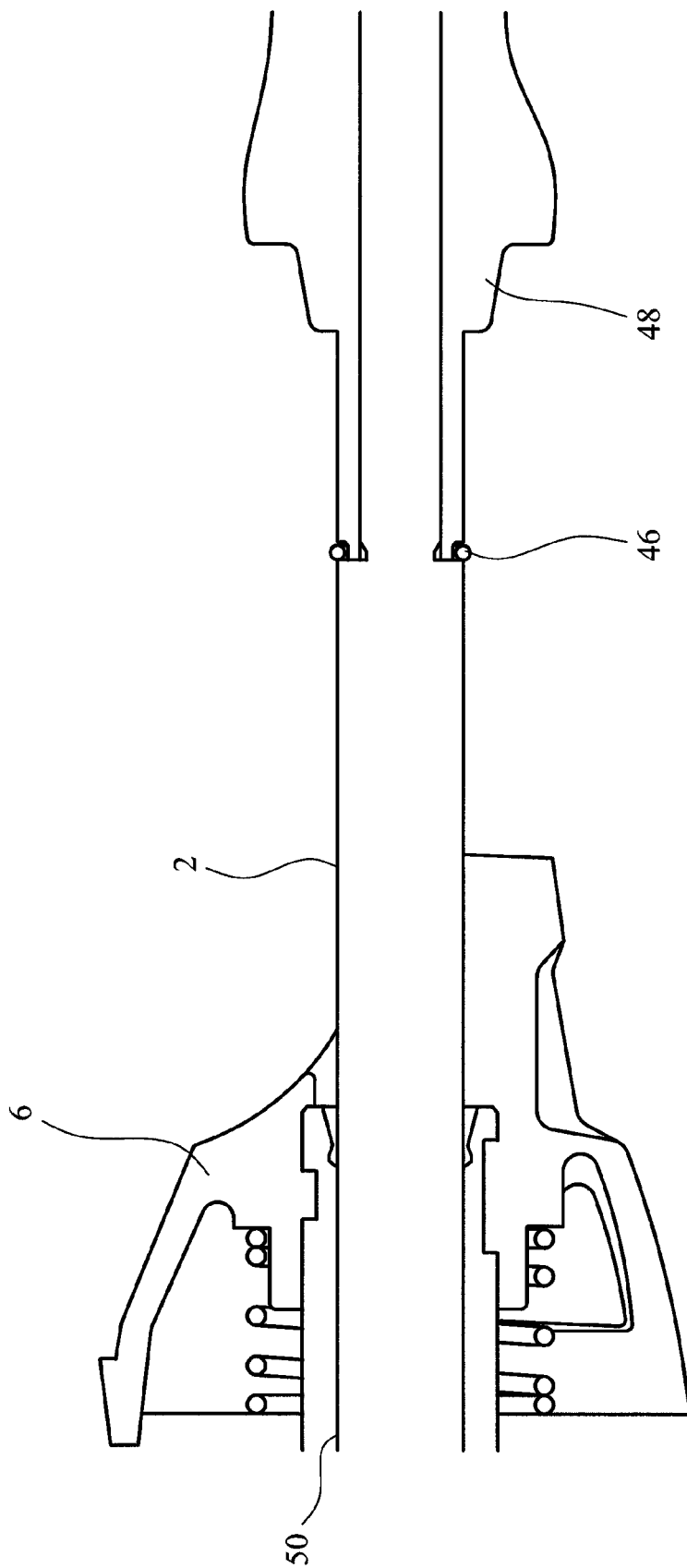


FIG. 8

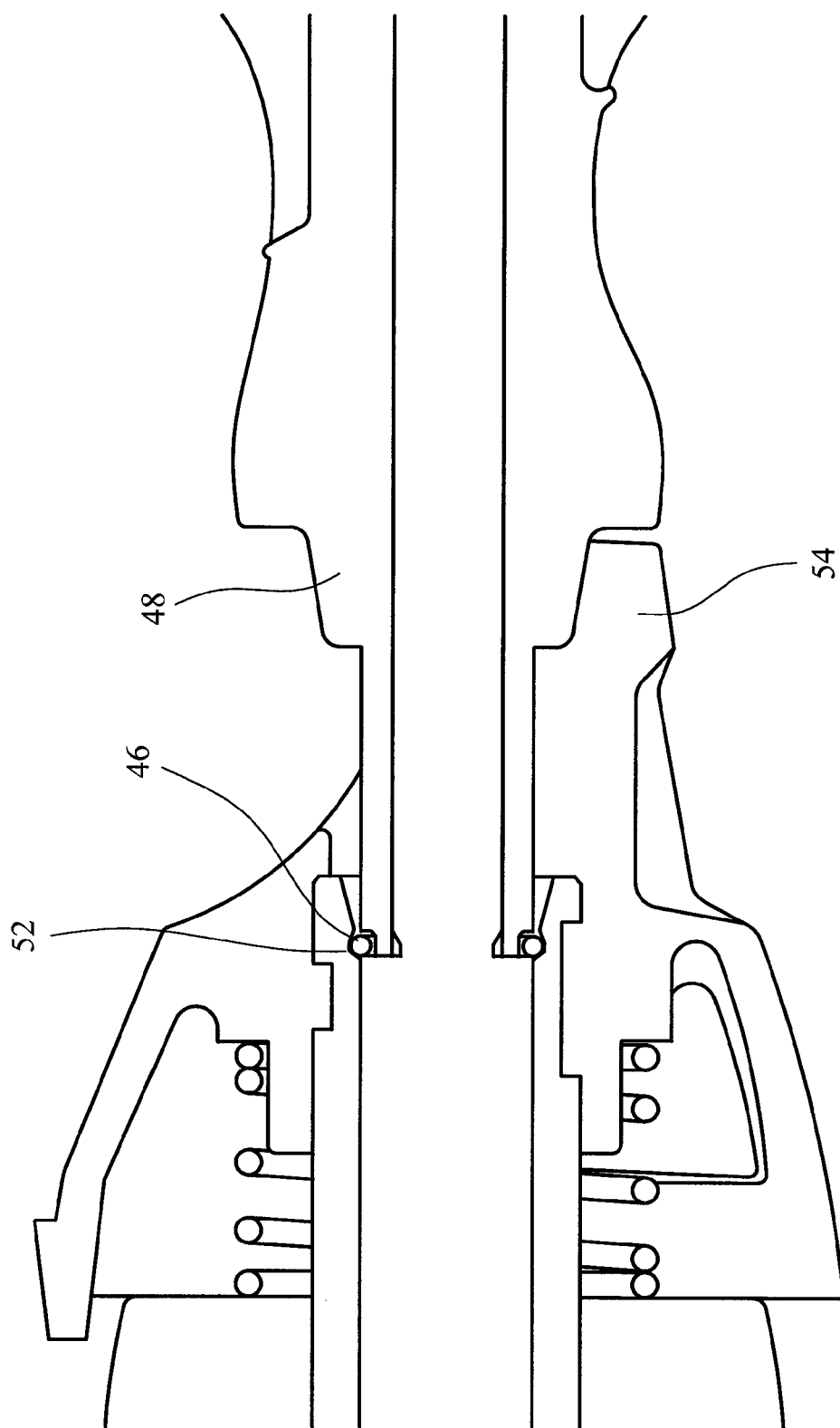


FIG. 9

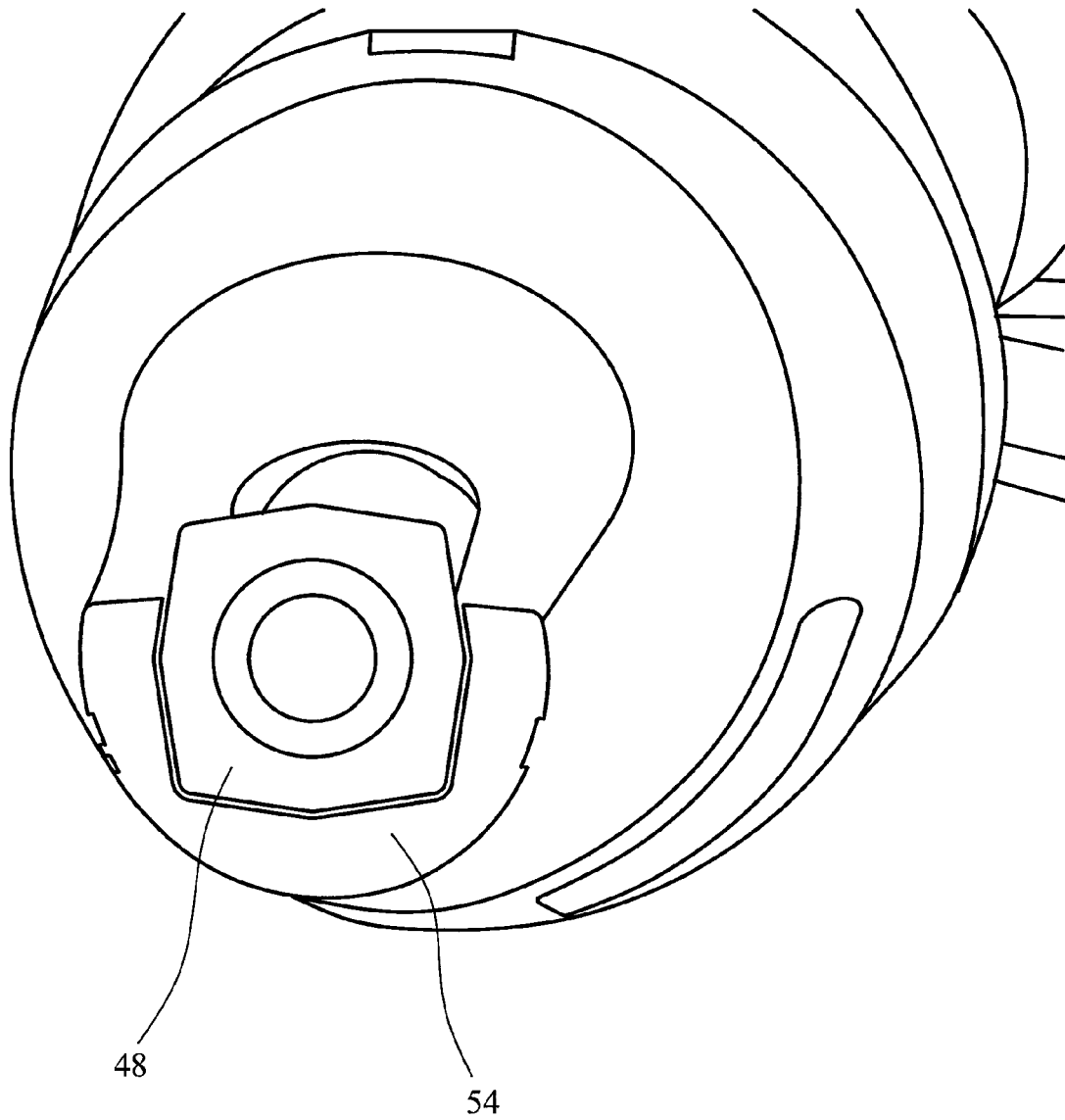


FIG. 10



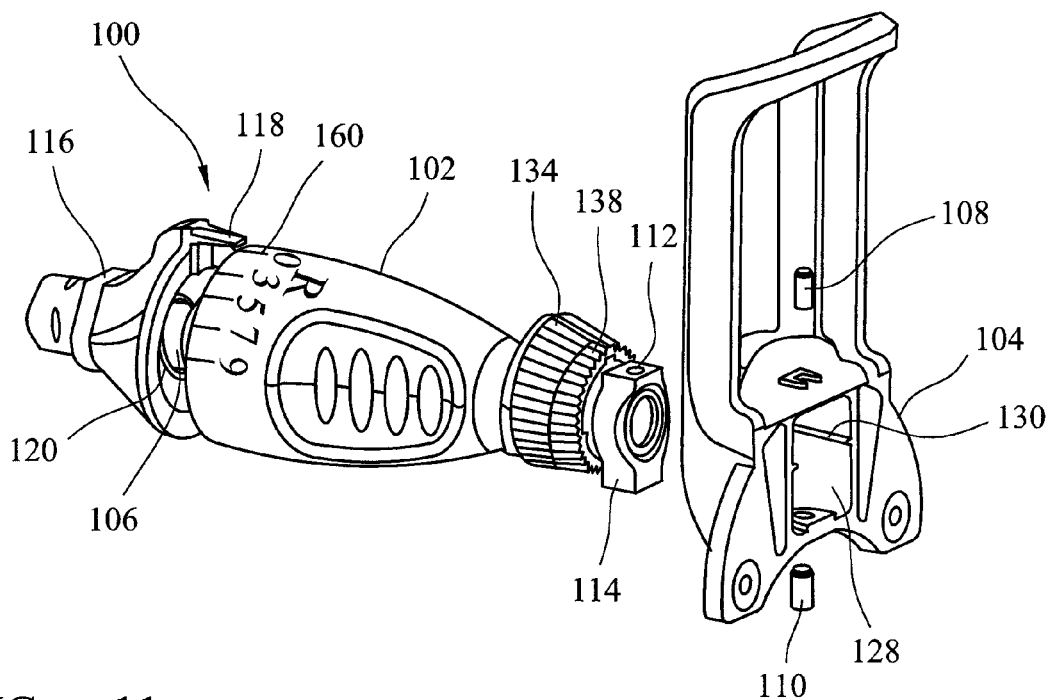


FIG. 11

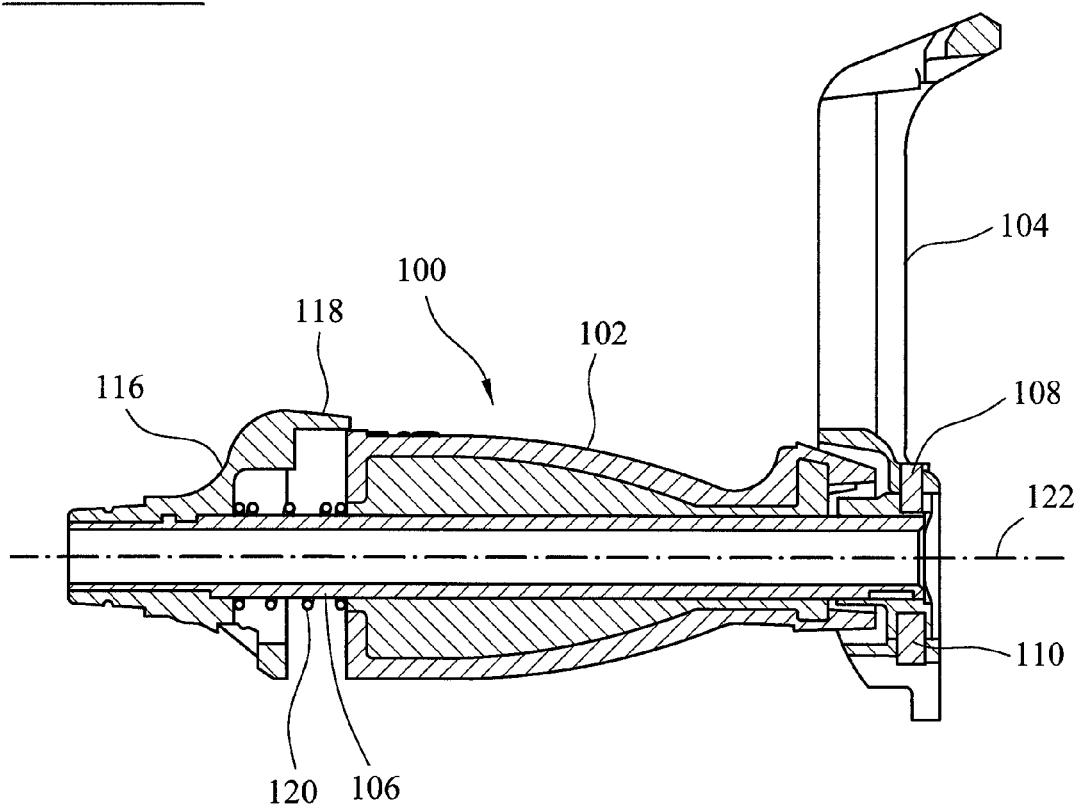


FIG. 12

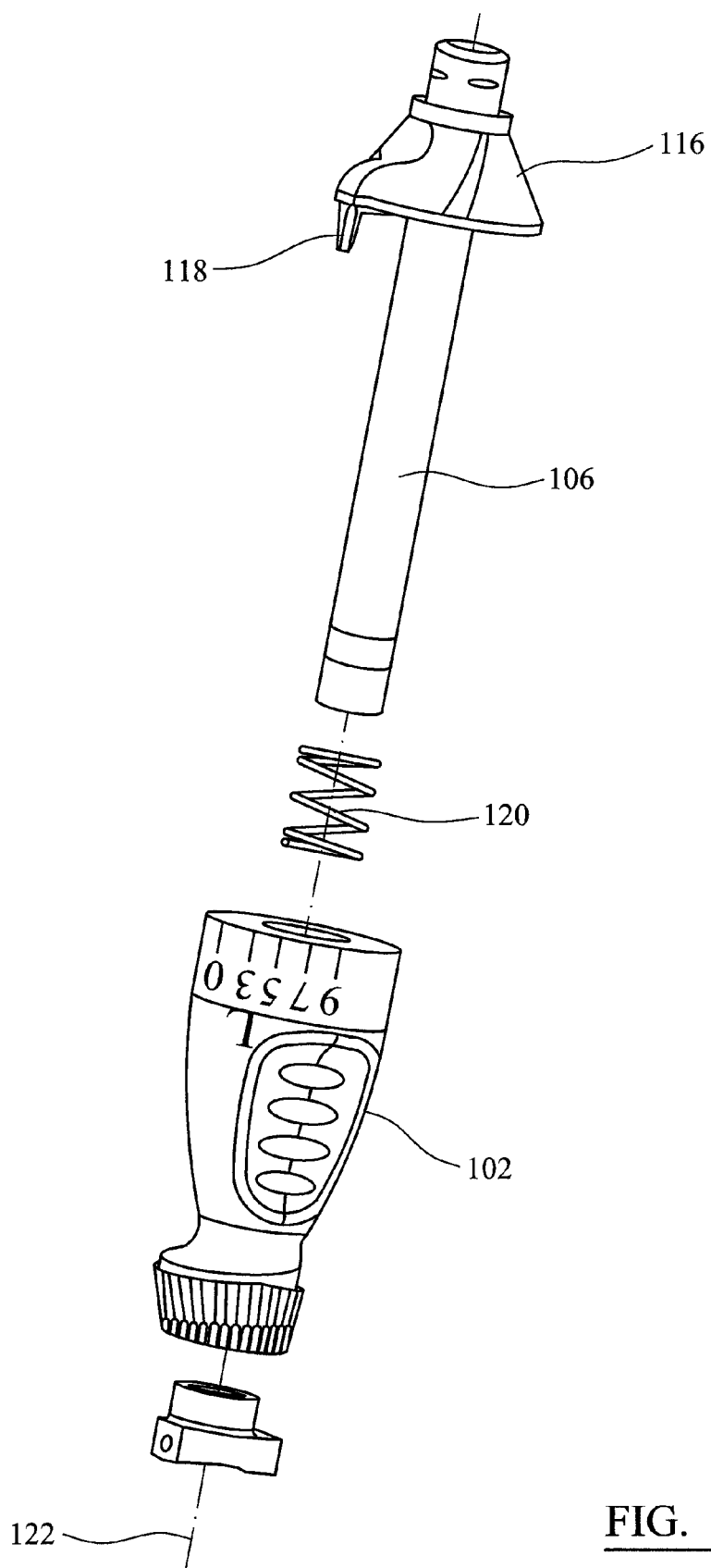


FIG. 13

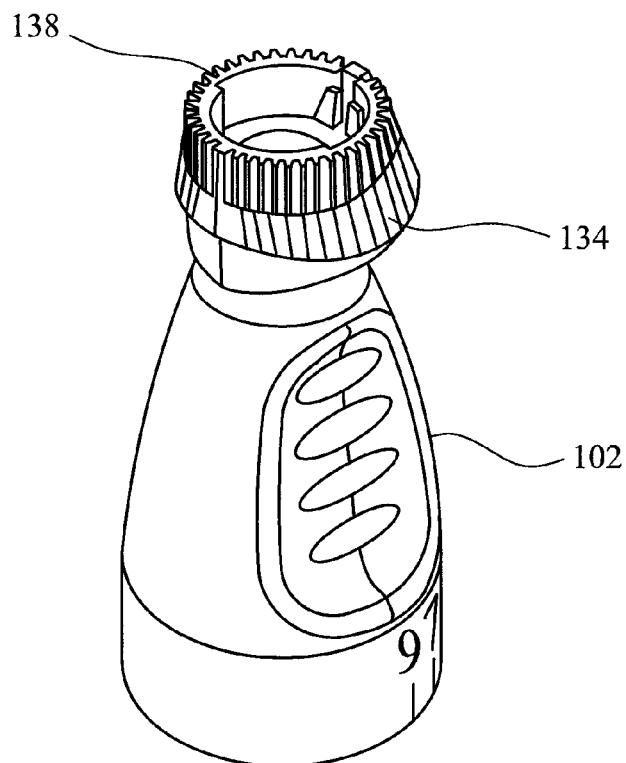


FIG. 14

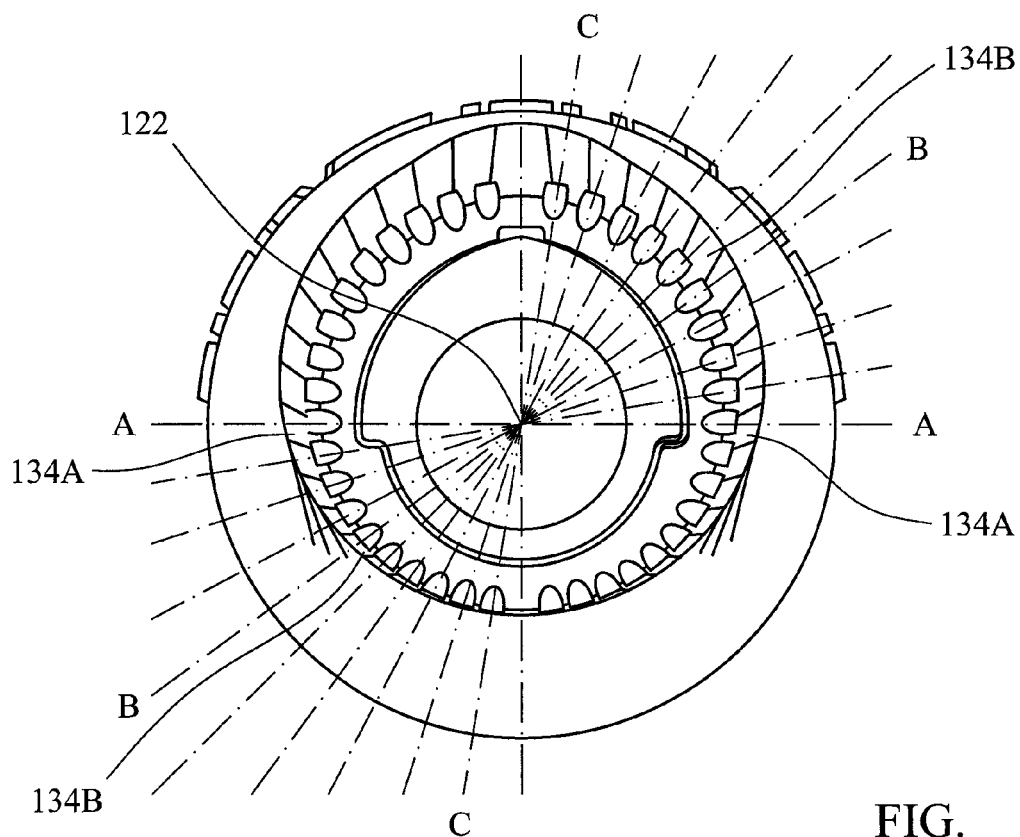


FIG. 15

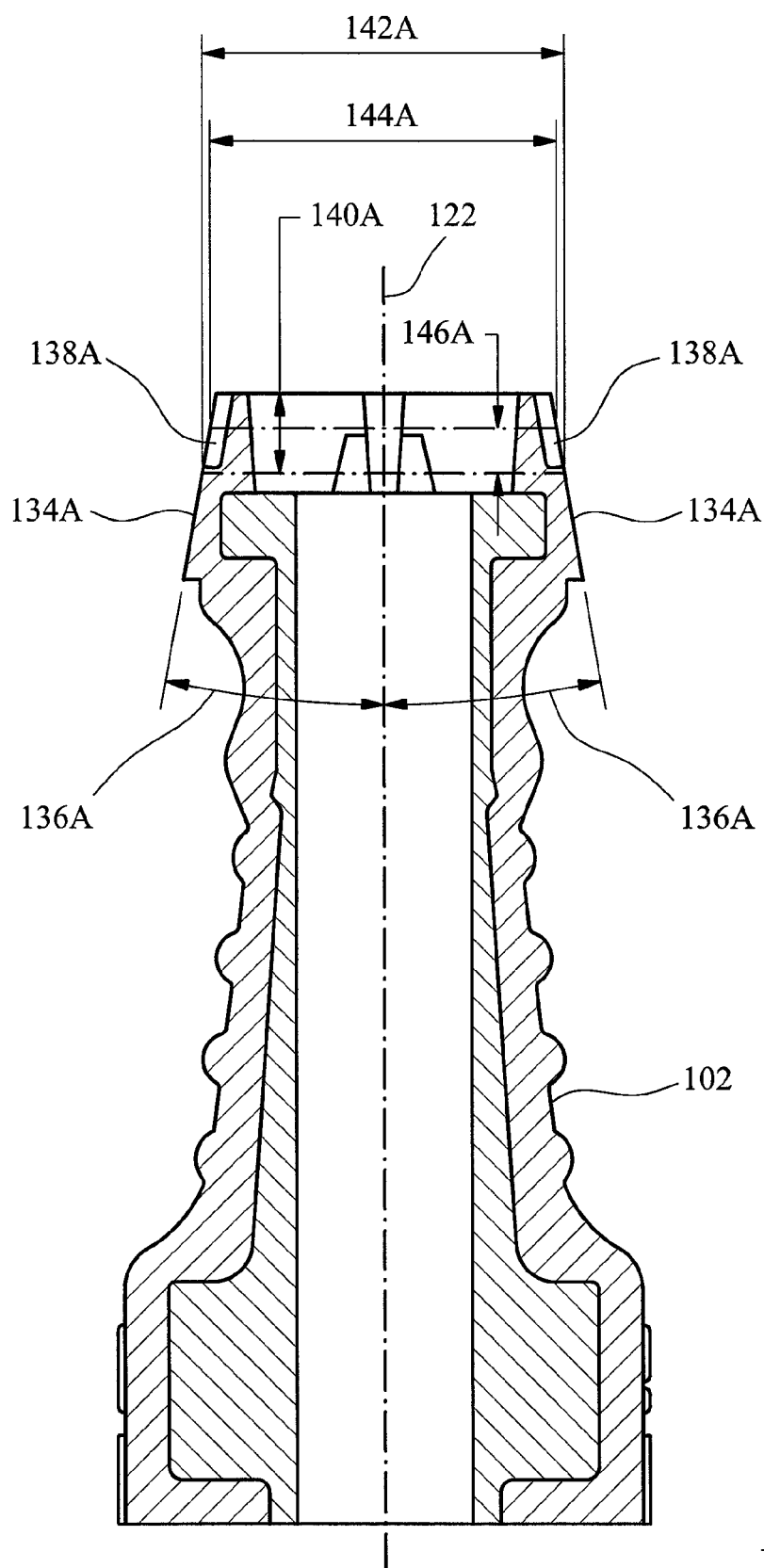


FIG. 16A

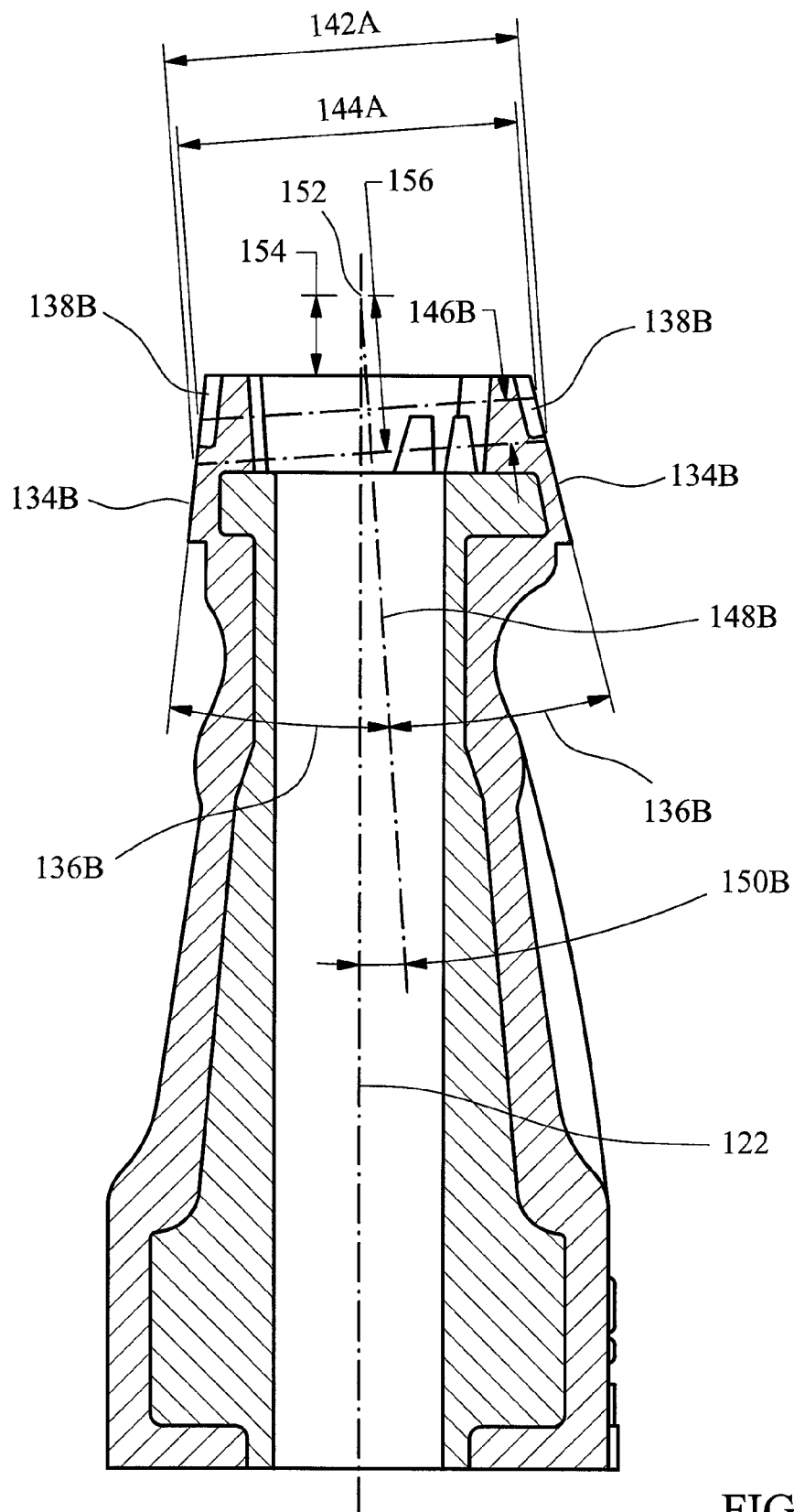


FIG. 16B

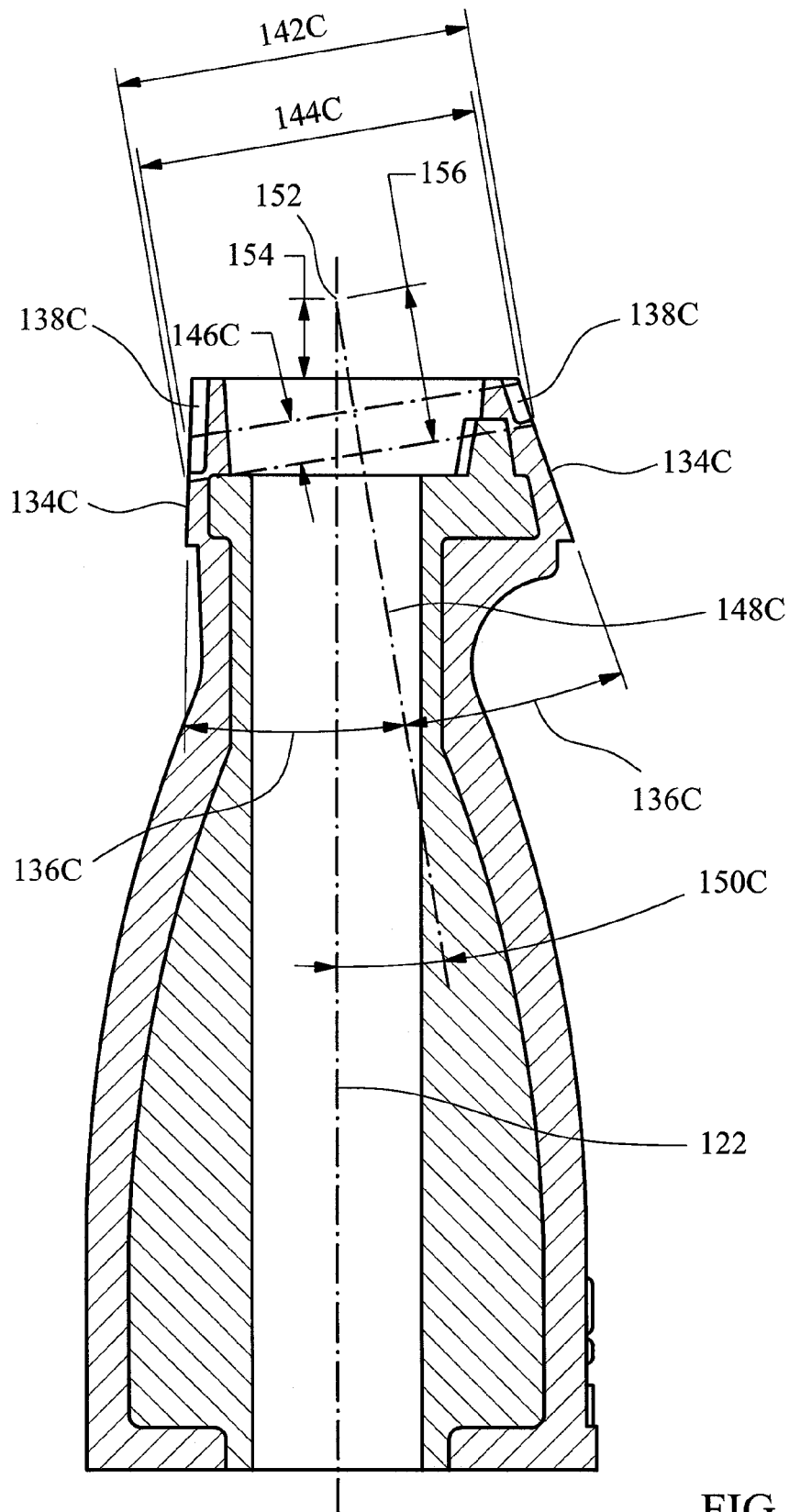


FIG. 16C

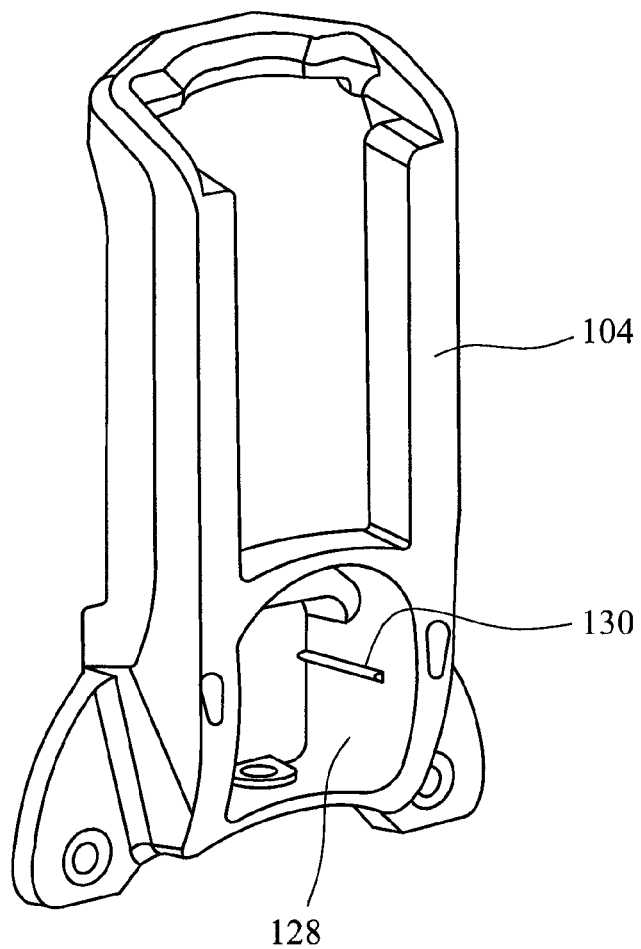


FIG. 17

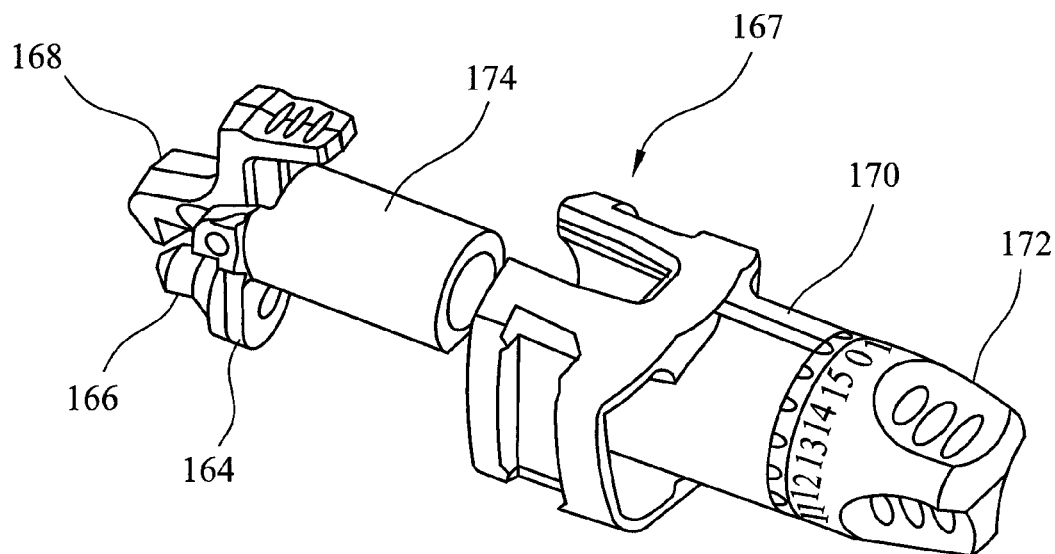
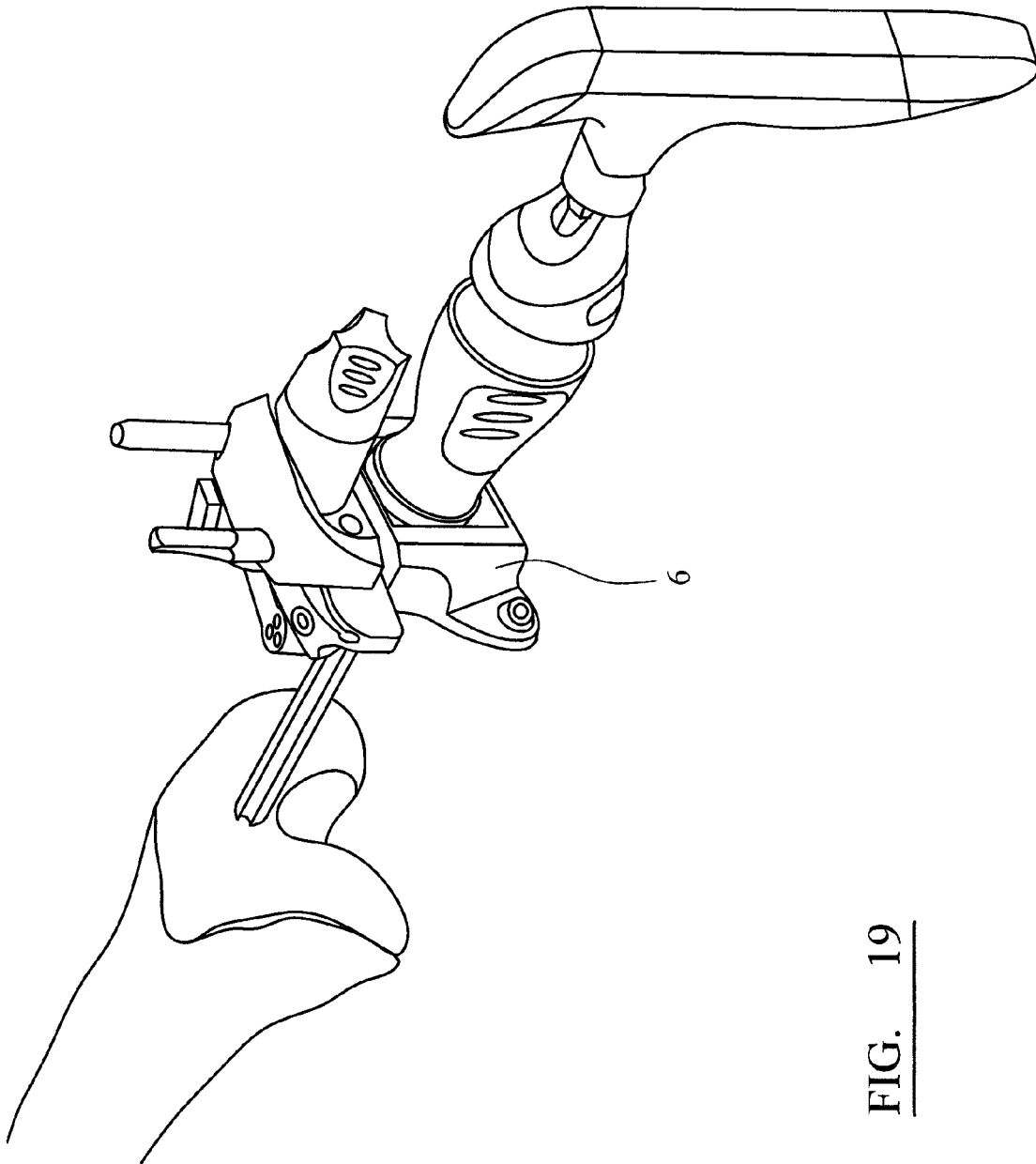


FIG. 18



**FIG. 19**



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# **SURGICAL CUTTING GUIDE, SURGICAL ALIGNMENT GUIDE AND SURGICAL INSTRUMENT SYSTEM**

## **CROSS REFERENCE TO RELATED APPLICATION**

This application is a National Stage 35 U.S.C. 371 of International Patent Application PCT/GB2011/052171 filed Nov. 8, 2011.

## **BACKGROUND OF THE INVENTION**

The present invention relates to a surgical cutting guide and a surgical alignment guide for use with the surgical cutting guide. Together the surgical alignment guide and surgical cutting guide form a surgical instrument system. The present invention is particularly applied to orthopaedic surgery and especially knee surgery.

## **BRIEF SUMMARY OF THE INVENTION**

In orthopaedic knee surgery, a cut may be made to the femoral head in order to correct varus or valgus alignment. A cutting guide is used to locate the cut accurately. The cutting guide is fixed to the bone using pins and provides a stable surface to guide resection of the femoral head.

In order to ensure the cutting guide is placed correctly on the femur, an alignment system is typically used. An intramedullary rod is inserted into the intramedullary canal of the femur, providing a stable reference to the intramedullary axis of the femur. An alignment guide is disposed on this rod. The alignment guide contains a scale indicating the desired angle of the cut relative to the intramedullary axis of the femur. The cutting guide is attached to the alignment guide and advanced along the rod until it is in contact with the femur, where it is aligned at the desired angle by the alignment guide. It can then be secured in place.

Once the cutting guide is secured in place, it can be difficult to remove the alignment guide without disturbing the positioning of the cutting guide, even though it is fixed in the bone. The cutting guide is perpendicular to the mechanical axis (which extends from the condylar notch to the femoral head). This mechanical axis is offset by about 7° relative to the anatomic axis, which is followed by the intramedullary rod. This makes withdrawal of the alignment guide and rod from the bone because they are not aligned. It can apply undesired forces to the cutting guide and result in variation of the alignment of the cutting guide with respect to the varus valgus alignment and also with respect to the distal face of the femur which is to be cut, which can lead to inaccuracy in the flexion-extension available from the implant.

It would be desirable to provide a surgical instrument system in which an alignment guide can be removed from a cutting guide more easily once the cutting guide has been affixed to the bone.

Accordingly, the present invention provides an alignment guide which includes an attachment protrusion with a stepped surface. The attachment protrusion is received in a corresponding recess formed in the cutting guide. The stepped surface enables greater freedom of movement between the cutting guide and alignment guide when the alignment guide is not completely removed from the cutting guide, once the steps are disengaged.

In one embodiment, a surgical cutting guide comprises a body section which delimits a recess extending into the body section from an external surface, wherein the recess has a

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central axis, is for receiving an attachment protrusion from a surgical alignment guide and comprises:

a first portion having a first constant cross section along the central axis; and

a second portion having a second constant cross section along the central axis which is larger than the first constant cross section;

and wherein the first and second portions are coaxial with the central axis and the second portion is closer to the external surface than the first portion. The first and second portions may be cylindrical, in that case the diameter of the second portion is larger than the diameter of the first portion.

Unlike the connection between prior art alignment guide and cutting guide, the provision of a recess with first and second portions with different constant cross sections, means that disengagement can be achieved over a much shorter distance. Once the two portions are disengaged, the first cylindrical portion is moved into an area with greater space than with a prior art connection. This enables more freedom of movement between an attachment protrusion and the recess, simplifying removal of an alignment guide from a cutting guide and reducing the risk of the position of the cutting guide being moved during removal.

In one embodiment the first and second portion may be less than 2 mm long measured along the longitudinal axis, more preferably 1.5 mm or less long. This means that within a very short movement along the longitudinal axis, the portions can be disconnected, giving more freedom of movement. This small distance minimises the effect of the misalignment of anatomical and mechanical axes.

In one embodiment, the recess may comprise a surface between the first and second cylindrical portions which is substantially perpendicular to the central axis. This provides a stepped profile to the recess and enables the space in the recess to increase quickly once the cylindrical portions are disconnected, giving greater freedom of movement.

The recess may comprise an enlarged central portion, between the first and second cylindrical portions, which has the greatest dimension in a plane perpendicular to the central axis that is greater than the second diameter. This can allow even freedom of movement, because the attachment protrusion can be oriented to a greater angle relative to the recess for removal.

The enlarged central section, if present, can extend completely through the body in a direction perpendicular to the central axis of the recess. This allows it to function as an attachment surface for a retaining clip of an alignment guide to ensure that when an attachment protrusion is present within the recess, it is held securely in place.

In another aspect of the invention, a surgical alignment guide comprises an attachment protrusion extending from an external surface, wherein the attachment protrusion has a central axis and comprises:

a first portion having a first constant cross section along the central axis; and

a second portion having a second constant cross section along the central axis that is larger than the first constant cross section;

wherein the first portion is further from the external surface than the second portion, and the first and second portions are coaxial with the central axis. The first and second portions may be cylindrical, in which case the second portion has a larger diameter than the first portion. The first and second portions share a common axis and therefore allow the cutting guide to be aligned correctly with

that axis. As discussed above, the use of two portions can allow a stepped profile to the attachment protrusion, simplifying removal.

In one embodiment a frustoconical portion may be provided between the first portion and the second portion. This can allow the transition from the first diameter to the second diameter to be achieved with a strong construction. In other embodiments, the apparatus may further comprise a surface which is substantially perpendicular to the central axis between the first portion and the second portion, creating a stepped profile.

The surgical alignment guide and the surgical cutting guide described above are combined to provide a surgical instrument system in another aspect of the invention.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will now be explained by way of example and not limitation with reference to the accompanying drawings, in which:

FIG. 1 depicts a perspective view of an alignment guide, cutting guide and intramedullary rod before connection of the cutting guide to the alignment guide;

FIG. 2 depicts a perspective view of an alignment guide, cutting guide and intramedullary rod as shown in FIG. 1, after the cutting guide has been connected to the alignment guide.

FIG. 3 shows a plan view of the system of alignment guide, cutting guide and rod of FIG. 2;

FIG. 4 depicts a cross-section through the attachment protrusion and corresponding recess when the alignment guide has been connected to the cutting guide;

FIGS. 5a-5e show cross-sections through the alignment guide and cutting guide showing the disconnection of the alignment guide from the cutting guide;

FIG. 6 depicts an intramedullary rod for use with the cutting guide and alignment guide of the system;

FIG. 7 depicts a perspective view of an alignment guide installed on the intramedullary rod of FIG. 6;

FIG. 8 depicts a cross-section through the intramedullary rod and alignment guide before the alignment guide is secured on the intramedullary rod;

FIG. 9 depicts a cross-section through the intramedullary rod and alignment guide after the alignment guide is secured on the intramedullary rod;

FIG. 10 depicts a cross-section showing a rotation limiting connection between the alignment guide and the intramedullary rod;

FIG. 11 depicts a perspective view of an alternative alignment guide;

FIG. 12 depicts a cross section of the alignment guide of FIG. 11;

FIG. 13 depicts an exploded view of selected components of the alignment guide of FIG. 11;

FIG. 14 depicts a perspective view of an adjustment member of the alignment guide of FIG. 13;

FIG. 15 depicts an end view of the adjustment member of FIG. 14;

FIGS. 16A-16C depict cross sections through the adjustment member of FIG. 14;

FIG. 17 depicts a perspective view of a pivoting member of the alignment guide of FIG. 13;

FIG. 18 depicts an exploded view of a cutting guide attachment part for use with the alignment guide of FIG. 16; and

FIG. 19 depicts a perspective view of an alignment guide, cutting guide and intramedullary rod with the intramedullary rod inserted to the intramedullary canal of a femur.

#### DETAILED DESCRIPTION OF THE INVENTION

FIG. 1 depicts a perspective view showing components of a surgical instrument system for aligning a cutting guide. The system comprises an intramedullary rod which comprises a cylindrical member 2 having longitudinal grooves 4 formed along its length. In use the cylindrical section 2 is inserted into the intramedullary canal of a femur and the longitudinal grooves 4 provide means for pressure release during insertion.

An alignment guide 6 (shown partially in FIG. 1) comprises a through bore into which the cylindrical section 2 of the intramedullary rod is inserted, so that the alignment guide 6 can move longitudinally along the cylindrical section 2 and also rotate relative to the cylindrical section.

A cutting guide 8 is provided separately from the alignment guide 6. The cutting guide 8 comprises a cutting slot 10 which defines the cut to be made to the bone. Cutting guide 8 also comprises attachment holes 12 for fixing the cutting guide 8 to the bone. Cutting guide 8 is attached to the alignment guide 6 by means of a recess 14 and an attachment surface 16 on its upper surface. The recess 14 has a shape corresponding to an attachment protrusion 18 formed on the alignment guide 6.

Attachment protrusion 18 comprises a first cylindrical portion 20 having a first diameter and a second cylindrical portion 22 having a second diameter which is larger than the first diameter. The first diameter is about 4 mm and the second diameter is about 12 mm in this embodiment. Other dimensions may be used in other embodiments. The first and second cylindrical portions 20, 22 share a common axis. Joining the first cylindrical section to the second cylindrical section 22 is a generally frustoconical portion 24. The recess 14 defines surfaces corresponding to the first and second cylindrical portions 20, 22 of the attachment protrusion 18.

In use, when the attachment protrusion 18 is inserted into recess 14, first cylindrical portion 20 and second cylindrical portion 22 engage corresponding surfaces within the recess so that the cutting guide 8 is securely aligned with the longitudinal axis of the attachment protrusion 18. The dimensions of the corresponding surfaces within the recess are close to the dimensions of the first cylindrical portion 20 and the second cylindrical portion 22 but very slightly larger. This ensures firm connection but reduces the likelihood of a tight fit between the attachment protrusion 18 and the recess 14 making it difficult to remove the attachment protrusion 18 from the recess 14.

The cutting guide 8 is further secured in place on the attachment protrusion 18 of the alignment guide 6 by a clip member 26 on the alignment guide 6. The clip member 26 engages the attachment surface 16 of the cutting guide 8. A perspective view of the cutting guide 8 installed on the alignment guide 6 can be seen in FIG. 2.

FIG. 3 shows a plan view of the system of alignment guide 6, cutting guide 8 and rod assembled together. FIG. 3 also depicts two adjustment scales 28, 30 provided on the alignment guide 6. The two adjustment scales 28, 30 allow the relative rotation of parts of the alignment guide to be set as determined by a surgeon to alter the varus valgus rotation of the attachment protrusion 18 relative to the intramedullary axis defined by the cylindrical portion 2 of the rod and the through bore in the alignment guide 6. The cutting guide 8 is installed on the attachment protrusion 18 and hence its alignment is altered relative to the intramedullary axis.

FIG. 4 depicts a cross-section of the assembled system, taken through the connection recess. This shows how the cutting guide is secured on the alignment guide by the engagement of cylindrical portions 20, 22 in corresponding

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sections of the recess. FIG. 4 also enables the internal construction of the connection recess 14 to be understood more clearly. The cross-section illustrates enlarged portion 32. Enlarged portion 32 includes an initial section perpendicular to the longitudinal axis of the recess following a short tapered section 34 from the first cylindrical section. Enlarged section 32 has a greatest dimension perpendicular to the longitudinal axis which is larger than the diameter of the second cylindrical section. This provides a greater range of movement for the first cylindrical section 20 within the recess during disconnection of the alignment guide 6 from the cutting guide 8. Tapered section 34, adjacent the first cylindrical section 36 of the cutting guide 8 serves to guide the tip of the attachment protrusion 18 into the first cylindrical section 36.

The enlarged central section 32 extends perpendicular to the longitudinal axis through the entire depth of the cutting guide. This allows the enlarged central section to also provide attachment surface 16 for clip 26.

The second cylindrical section is formed in the portion of the cutting guide adjacent cutting slot 10.

The disconnection of the cutting guide from the alignment guide will now be described. To illustrate the benefits of this system, the cutting guide is depicted in FIG. 5a connected to the alignment guide 6 with the varus valgus adjustment 28 of the alignment guide adjusted to a maximum in the right-hand direction. This shifts the angle of the longitudinal axis of the attachment protrusion 18 and cutting guide 8 relative to the longitudinal axis of the cylindrical section 2, and can clearly be seen in FIG. 5a. In prior art devices this configuration can be difficult for a surgeon to disconnect the alignment guide from the cutting guide. The difference in angles between the anatomic axis (defined by the cylindrical section 2 of the rod) and the mechanical axis, in addition to the offset of the attachment protrusion with the alignment guide make it difficult to remove cleanly. The alignment guide is constrained by the cylindrical section 2 to move along the anatomical axis, not mechanical axis.

As shown in FIG. 5b, in the present system, after relatively little movement, for example as small as 1.5 mm, the first and second cylindrical sections of the connection are disengaged. After a further short movement, the first cylindrical section of the attachment protrusion enters the enlarged section 32 of the recess in the cutting guide. At this point, there is significant freedom of movement between the attachment protrusion 18 of the alignment guide and the recess 14 of the cutting guide. As shown in FIG. 5d, the disconnection of the cylindrical sections enables simple removal of the attachment protrusion along the anatomical axis defined by cylindrical section 2, without needing complicated manipulation, until as shown in FIG. 5e the attachment protrusion 18 is well clear of the cutting guide. The cylindrical section of the rod can then be withdrawn from the intramedullary canal, leaving the cutting guide in place.

Unlike prior art systems, the stepped nature of the attachment protrusion 18 and corresponding recess, including first and second cylindrical portions with different diameters, enables disconnection of an attachment protrusion to be achieved over much shorter distances. This gives greater freedom of movement between the parts, simplifying separation of the alignment guide from the cutting guide after the cutting guide is in place. This can allow a user more freedom in choice of the technique used to disconnect the cutting guide and allow one handed removal in certain circumstances.

The system is used with an intramedullary rod 40 which is illustrated in its entirety in FIG. 6. The intramedullary rod 40 comprises a handle 42, a cylindrical section 2 having grooves 4 formed therein (as described above) and a rounded end 44 at

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the distal end of the cylindrical section 2, furthest from the handle 42. At a proximal end of the cylindrical section 2, close to the handle 42, a protrusion 46 is provided which extends circumferentially around the cylindrical section 2. Proximal of the protrusion 46, a second protrusion 48 is formed around the longitudinal axis defined by the cylindrical section 2. As will be described in more detail below, protrusion 46 and protrusion 48 form parts of a restraining system for retaining an alignment guide in position on the intramedullary rod 40 while the rod 40 is being inserted or removed from an intramedullary canal.

The protrusion 46 is about 65 mm from the proximal end of the handle 42. This distance, and the length of the rod 40, may be varied depending on the length of rod 40 required to extend beyond an alignment guide 6 when engaged with the restraining system. For example, the rod 40 may extend up to 300 mm. In use the rod 40 may not be inserted into an intramedullary canal to its full length. The depth of insertion may be limited, for example by a hip stem already present in the canal from an earlier hip replacement procedure. To allow for this, the alignment guide 6 can be released from the restraining system and moved along the rod 42 to engage the bone surface.

FIG. 7 depicts a perspective view of the proximal end of an intramedullary rod 40 with an alignment guide 6 mounted thereon. A cross-section showing the way in which the alignment guide 6 is mounted on the intramedullary rod 40 is given in FIG. 8. FIG. 8 depicts how the alignment guide 6 comprises a through bore 50 which receives cylindrical section 2 of the intramedullary rod 40. As depicted in FIG. 8, the alignment guide 6 can be moved freely along the longitudinal axis relative to the rod and rotated relative to that axis. During insertion and removal of the intramedullary rod to the intramedullary canal, the free movement of the alignment guide can mean that two hands are required, one to insert the rod and the other to ensure that the alignment guide does not move relative to the rod during insertion.

To secure the alignment guide relative to the rod, FIG. 9 shows how protrusions 46, 48 engage corresponding features in the alignment guide to prevent longitudinal movement of the alignment guide along the rod and also to prevent rotation of the alignment guide relative to the rod. Ring shaped protrusion 46 on the intramedullary rod is formed from a resilient material. This engages a corresponding groove 52 in the through bore 50 of the alignment guide 6. The resilient nature of the protrusion 46 means that it can be compressed by a small force before expanding into the groove 52. This holds the alignment guide 6 securely on the rod 40, preventing relative longitudinal movement.

In some embodiments, the protrusion 46 may be made of a material with a high coefficient of friction so that it can also prevent rotation of the alignment guide about the longitudinal axis as well as longitudinal movement. However, a second protrusion 48 may also be provided to prevent rotation. Although not clear from the cross-section in FIG. 9, protrusion 48 has a polygonal shape centred on the longitudinal axis. This engages a corresponding recess 54 formed in the alignment guide. FIG. 10 shows the engagement between protrusion 48 and recess 54 more clearly. Protrusion 48 has a generally octagonal shape centred on the longitudinal axis. Together, the engagement of protrusion 48 with the recess 54 prevents rotation of the alignment guide 6 relative to the rod 40 when the first protrusion 48 is engaged with groove 52.

Thus, the connection between the rod and the alignment guide can be made secure during insertion or removal of the intramedullary rod. When it is desired to use the alignment guide 6 to place the cutting guide 8 in the correct position, the

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alignment guide 6 is moved longitudinally in a distal direction to disengage both protrusion 48 from channel 54 and protrusion 46 from groove 52. Alignment guide 6 is then free to translate and rotate about longitudinal axis of the cylindrical section 2.

FIG. 11 depicts a perspective view of an alignment guide 100 which allows a fine degree of control over the angular adjustment. As shown in FIG. 11, the alignment guide comprises an adjustment member 102 and a pivoting member 104. The adjustment member is disposed over a longitudinal shaft 106 which defines a longitudinal axis. Longitudinal shaft 106 is hollow, enabling the alignment guide to be installed on an intramedullary rod (not shown). The pivot member 104 is pivotally attached to the shaft 106 by passing pins 108, 110 through openings defined in the pivot member 104 and engaging corresponding openings 112, 114 formed in an end of the shaft 106.

An indicator member 116 is provided at the other end of the shaft to the pivotal connection. This includes a pointer 118 which extends over the end of the adjustment member 102 to overlap a visual indicia of the degree of angular adjustment applied by the adjustment member 102.

The adjustment member 102 is shorter than the distance between the end of indicator member 116 and the pivot point 112, 114. This enables adjustment member 102 to translate back and forth along the longitudinal axis 122. A resilient member 120, which is a helical spring in this embodiment, is disposed around the shaft 106. This provides a force to push the adjustment member 102 towards the pivot point 112, 114 in the absence of an applied force.

The assembled alignment guide 100 is shown in cross-section in FIG. 12. This enables the relationship of the various components to the longitudinal axis 122 to be seen clearly. FIG. 13 depicts an exploded diagram showing the construction between the shaft 106, resilient member 120 and adjustment member 102.

Adjustment member 102 includes an end portion which comprises a plurality of pairs of facets 134. Each pair of facets 134 is contiguous with another pair of facets 134. The forward end of the edge between each pair of facets comprises a cut away portion 138. The configuration of the facets 134 and cut away portions 138 will be described in more detail below.

The pivoting member 104 comprises a recess 128 for receiving the end portion of the adjustment member. The recess 128 includes projections 130. The projections 130 are positioned to engage one pair of facets 134 when the end portion of the adjustment member 102 is located in the recess. In the absence of an applied force, the force provided by resilient member 120 ensures that a pair of facets 134 is engaged with the projections 130 of the recess 128. The configuration of the recess 128 and projections 130 can be seen more clearly in FIG. 17 which is a perspective view of the pivoting member from the opposite direction to that shown in FIG. 11.

In use, the interaction between a pair of facets 134 on the adjustment member 102 with the projections 130 on the recess 128 acts to rotate the pivoting member about the axis defined by the pins 108, 110. This pivoting is achieved by the specific arrangement of facets 134 provided on the adjustment member 102. The arrangement of these facets will now be described with reference to FIGS. 14, 15 and 16A-16C.

FIG. 14 depicts a perspective view of the adjustment member 102. It shows how the adjustment member comprises a plurality of facets 134 at one end. Facets 134 are arranged in mutually opposed pairs about the longitudinal axis. The configuration of each pair of facets 134 is chosen so that they define an axis which is angled with respect to the longitudinal

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axis. FIG. 15 depicts an end view of the adjustment member 102. It shows how the facets are evenly spaced at regular angular spacings around the longitudinal axis 122. In this embodiment, there are nineteen pairs of facets respectively defining angles of  $0^\circ$  and  $\pm 9^\circ$ .

FIG. 16A shows a cross-section along line A-A in FIG. 15. This pair of facets 134A defines an axis which is coincident with the longitudinal axis 122, or at an angle of  $0^\circ$ . In this example, all of the pairs of facets 134 define a taper of  $20^\circ$ . Thus, both facets 134A are offset by  $10^\circ$  from the longitudinal axis to define a taper of  $20^\circ$ . This angular adjustment is indicated by arrows 136A in FIG. 16A.

As discussed above, to facilitate rotation of the adjustment member 102 when it is disengaged from the recess, cut outs 138 are provided at the end. Cut outs 138A depicted in FIG. 16A extend approximately 5.5 mm from the end of the adjustment member 102. This is indicated by reference numeral 140A. The width of the adjustment member just before the cut out is approximately 25 mm, indicated by reference number 142A. Dimension 144A is approximately 24 mm, showing the taper and dimension 136A is approximately 3 mm. Other dimensions may be used in other embodiments depending on the particular requirements.

For an angle of  $0^\circ$ , i.e. an axis which is coincident with the longitudinal axis FIG. 16A shows that the configuration of the end portion in cross-section at the pair of facets 134A is symmetrical. Thus, when pair of facets 134A engage the projections 130 the recess is rotated to be aligned with the longitudinal axis.

FIG. 16B depicts a cross-section along line B-B in FIG. 15. At this position, the pair of facets 134B together define an angled axis 148B with respect to the longitudinal axis 122. As indicated by angular dimension 150B, the angled axis 148B is  $4^\circ$  offset from longitudinal axis 122. Angled axis 148B is defined by facets 134B which have been rotated about a point 152. Point 152 lies on the longitudinal axis 122 approximately 5.5 mm from the top of the adjustment member 102, as indicated by distance 154. The taper of the facets 134B is the same as for facets 134A,  $20^\circ$ . However, the taper is defined with reference to the angled axis 148B. This means that when the facets 134B engage the projections 130 the pivoting member will be pivoted through  $4^\circ$  because of the self-centering nature of the taper. Point 152 is chosen to be coincident with the axis of pins 108, 110.

When facets 134B are engaged with pivoting member, the pivoting member is rotated relative to the longitudinal axis consistent with the rotation of the facets 134B along angled axis 148B. Thus, the cut out 138B extends a different distance either side of the adjustment member 102 to ensure that they are the same distance from the pivot member, when facets 134B are engaged by projections 130. Dimension 156 is approximately 11 mm from the pivot point 152. This 11 mm distance is measured in the direction of angled axis 148B. Thus, cut out 138B is shorter than cut out 138B'. Dimensions 142B, 144B and 146B correspond to dimensions 142A, 144A and 146A for consistency with all embodiments.

To further assist the explanation, FIG. 16C depicts a cross-section of the adjustment member 102 taken along line CC in FIG. 15. This corresponds to an adjustment of  $9^\circ$  as indicated by angle 150C in FIG. 16C. The angling of angled axis 148C is more pronounced in this cross-section. This means that the distance of cut outs 138C on the right hand side of the diagram is again shorter than the cut out 138C' on the left hand side. The length of the cut out is again determined by projecting a line approximately 11 mm from the pivot point 152 and extending the cutout 138C, 138C' in the direction of the angled axis 148C distance 156 (approximately 11 mm in this

embodiment). The remaining dimensions **142C**, **144C**, **146C** remain the same as **142A**, **144B** and **146C**.

FIG. **16C** demonstrates how the facets **134C** are still tapered with respect to the longitudinal axis **122**. This is because the taper angle of  $20^\circ$  means that with the  $9^\circ$  relative angle of axis **148C** there remains  $1^\circ$  of taper depicted on the left hand side of FIG. **16C**. This ensures that the taper remains with respect to the longitudinal axis (although it is not symmetrical about the longitudinal axis **122**).

In use, the angle of the pivoting member is adjusted by withdrawing the adjustment member **102** proximally against the biasing force of resilient member **120**. This disengages the facets from the projections in the pivoting member **104**. The adjustment member is then rotated until the indicator **118** points at the desired degree of angular adjustment. This is indicated by markings or indicia **160** on the adjustment member **102**. The adjustment member can then be released and the action of the resilient member **120** pushes the end of the adjustment member into the recess **128** of the pivoting member. The pair of facets **134** corresponding to the desired angular adjustment as indicated by indicator **118** engage projections **130**. The taper ensures that the pivoting member is centred and securely located on the facets. Depending on the angle of the axis defined by the pair of facets, the pivoting member is turned to the desired angle by the engagement of the facets with the projection.

In this embodiment, a cutting guide is attached to the pivoting member **104** by an intermediate translating assembly **162**. Translating assembly **162** comprises an attachment member **164** which includes a stepped connection **166** and clip **168** for attaching a cutting guide (not shown) and a translation adjustment mechanism **170**. Translation adjustment mechanism **170** comprises an adjustment dial **172** which adjusts the translation of the cutting guide relative to the alignment guide by adjusting the degree to which shaft **174** is inserted into a corresponding recess in translation adjustment guide **170**. (The parts of this assembly are shown in exploded form in FIG. **18** for clarity).

It will be appreciated that the configuration depicted in FIGS. **11-18** differs in some minor aspects of appearance with configuration depicted in FIGS. **1-10** and **19**. The features of angular adjustment and features of the adjustment member described in relation to FIGS. **11-18** can be applied to FIGS. **1-10** and **19**.

Where dimensions are described, they are for example only and are not limiting. Alternative dimensions may be used in other embodiments.

FIG. **19** depicts a system of alignment guide, rod, handle and cutting guide in use, inserted into a femur before the alignment guide is advanced along the rod to engage the cutting guide with the femur.

The improved connection between a cutting guide and an alignment guide may be used in other applications than for knee surgery, for example, it is applicable to any situation in which an alignment axis is not the same as a guiding axis. The stepped principle could also be applied to any system in which disconnection with short longitudinal movement is required. The connection between the alignment guide and the rod may be used in any circumstance in which an alignment guide is used with a rod, not only those where an alignment guide is used to install a cutting guide for knee surgery as described above. The improved angular adjustment mechanism may be used with any surgical instrument requiring angular adjustment, not only for use in knee surgery.

Although a system comprising an alignment guide, cutting guide and rod has been described, the stepped attachment

protrusion for connecting the cutting guide and alignment guide can be used in systems which do not include a rod. Likewise the restraining system between the alignment guide and rod can be used in systems which do not include a cutting guide. The stepped attachment system and the restraining system can be used with other alignment guides than the faceted guide described above, for example they may be used with the mechanism discussed in WO-A-2009/037471.

The elements of the above described system are constructed from medical grade materials. For example the rod may be manufactured from medical grade metal and the other components from medical grade plastics materials or metals.

The invention claimed is:

**1.** A surgical instrument system comprising a surgical alignment guide and a surgical cutting guide mountable on the surgical alignment guide, wherein:

the surgical alignment guide includes an external surface and an attachment protrusion extending from the external surface, the attachment protrusion having a central axis, wherein the attachment protrusion comprises a first portion having a first constant cross section over a first distance as measured between axially spaced locations along the central axis and a second portion connected to the first portion having a second constant cross section over a second distance as measured between axially spaced locations along the central axis, the second cross section being larger than the first constant cross section and wherein the first portion is more distal from the external surface than the second portion, and the first and second portions are coaxial with the central axis;

the surgical cutting guide includes:

a body comprising an external surface having a recess that extends from the external surface into the body, the recess defines a central axis and is sized to receive the attachment protrusion of the surgical alignment guide, and wherein the recess has:

a first portion having a first constant cross section over a first distance as measured between axially spaced locations along the central axis;

a second portion spaced from and communicating with the first portion, the second portion having a second constant cross section over a second distance as measured between axially spaced locations along the central axis, the second constant cross section being larger than the first constant cross section;

wherein the first and second portions are coaxial with the central axis and the second portion is closer to the external surface than the first portion; and

wherein the shapes of the first and second portions of the recess in the alignment guide correspond to the shapes of the first and second portions of the attachment protrusion so that when the attachment protrusion is inserted into the recess in the cutting guide, the central axis of the recess is aligned with the central axis of the protrusion.

**2.** The surgical instrument system of claim **1**, wherein the first and second portions of the protrusion and of the recess are cylindrical.

**3.** The surgical instrument system of claim **1**, wherein the recess is defined in part by a surface between the first and second portions which is substantially perpendicular to the central axis.

**4.** The surgical instrument system of claim **1**, wherein the recess has an enlarged central portion that is positioned between and communicates with the first portion and the second portion of the recess, the enlarged central portion having a greatest dimension in a plane perpendicular to the

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central axis, the greatest dimension being larger than the greatest dimension of the second portion of the recess.

5. The surgical instrument system of claim 4, wherein the enlarged central section extends through the body from the external surface to an opposing surface in a direction perpendicular to the central axis of the recess.

6. The surgical instrument system of claim 1, wherein: the recess includes a connecting portion extending between the first portion and the second portion of the recess;

the protrusion includes a connecting portion extending between the first portion and the second portion of the protrusion; and

the shape of the connecting portion of the protrusion is different than the shape of the connecting portion of the recess.

7. A surgical alignment guide, comprising: an external surface, an attachment protrusion extending from the external surface, the attachment protrusion having a central axis, and wherein the attachment protrusion comprises: a first portion having a first constant cross section over a first distance as measured between axially spaced locations along the central axis; a second portion connected to the first portion having a second constant cross section over a second distance as measured between axially spaced locations along the central axis, the second cross section being larger than the first constant cross section; and a frustoconical portion connecting the first portion and the second portion; wherein the first portion is more distal from the external surface than the second portion, and the first and second portions are coaxial with the central axis, wherein the alignment guide is part of an instrument system that includes an intramedullary rod; the alignment guide has a through bore so that the alignment guide is mountable on the intramedullary rod; and the attachment protrusion is offset from the intramedullary rod when the alignment guide is mounted on the intramedullary rod.

8. The surgical alignment guide of claim 7, further comprising a surface between the first portion and the second portion that is substantially perpendicular to the central axis.

9. The surgical alignment guide of claim 7, wherein the first and second portions are cylindrical.

10. A surgical instrument system comprising an intramedullary rod having a central longitudinal axis, a surgical alignment guide having a through bore by which the alignment guide can be mounted on the intramedullary rod, and a surgical cutting guide mountable on the surgical alignment guide, wherein:

(a) the surgical cutting guide comprises a body comprising an external surface having a recess that extends from the external surface into the body, the recess defining a central axis and having a first portion having a first constant cross section over a first distance as measured

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between axially spaced locations along the central axis and a second portion communicating with the first portion, the second portion being axially spaced from the first portion and having a second constant cross section over a second distance as measured between axially spaced locations along the central axis, the second constant cross section being larger than the first constant cross section, wherein the first and second portions are coaxial with the central axis and the second portion is closer to the external surface than the first portion;

(b) the alignment guide comprises an external surface and an attachment protrusion extending from the external surface, the attachment protrusion having a central axis, and wherein the attachment protrusion includes a first portion having a first constant cross section over a first distance as measured between axially spaced locations along the central axis and a second portion connected to and axially spaced from the first portion, the second portion having a second constant cross section over a second distance as measured between axially spaced locations along the central axis, the second cross section being larger than the first constant cross section, wherein the first portion is more distal from the external surface than the second portion, and the first and second portions are coaxial with the central axis;

wherein the cutting guide and the alignment guide can be connected and disconnected from each other by relative movement of one relative to the other along the central axis of the recess in the cutting guide, with the first portion of the protrusion being moved into and out of the first portion of the recess and the second portion of the protrusion being moved into and out of the second portion of the recess;

wherein the alignment guide can be mounted on the intramedullary rod so that the central axis of the protrusion defines a varus valgus angle with the central longitudinal axis of the intramedullary rod;

wherein the varus valgus angle between the central axis of the protrusion and the central longitudinal axis of the intramedullary rod is adjustable; and

wherein adjusting the varus valgus angle between the central axis of the protrusion and the central longitudinal axis of the intramedullary rod adjusts the alignment of the cutting guide when the cutting guide is mounted on the alignment guide.

11. The surgical instrument system of claim 10 wherein the protrusion is offset from the through bore of the alignment guide.

12. The surgical instrument system of claim 11 wherein the protrusion includes a frustoconical portion extending between the first portion and the second portion.

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